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A note on Teratological Aberrations in *Oochoristica* species

By

V. N. CAPOOR *and* V. C. SRIVASTAVA

Department of Zoology, University of Allahabad, India

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Teratological aberrations in Anoplocephalidae are varied and many. The foregoing description includes two such individuals of some interest of *Oochoristica* sp., collected from a wall-lizard *Hemidactylus flaviviridis* (Ruppel) from Malvianagar, Allahabad.

(A) One of the individuals shows the following aberrations :

1. Two of the immature proglottides, 0·56 mm. × 0·832 mm. and 1·92 mm. × 0·995 mm. at a distance of 1·5 and 2 cms. respectively from the anterior end, possess traces of two developing genitalia per proglottid ; one of the anlagen of genitalia located in the anterior half while the other in the posterior half of the segment (Fig. 1 and 3).

   Another proglottid, 0·752 mm. × 0·866 mm. at a distance of about 1·7 cms. from the anterior end possesses two sets of anlagen, closely set together in the anterior half (Fig. 2).

2. Again another proglottid of the same individual (Fig. 4) 1·08 mm. wide at a distance of 3 cms. from the anterior end, possesses obliquely reversed female genitalia. Here the vitelline glands are located anterior to ovary while vagina occupies the normal position, being posterior to cirrus sac. The testicular follicles are scattered mainly in the anterior half though a few are present posterior and aporal to the female glands.

3. Yet another proglottid of the same individual (Fig. 5), 1·25 mm. wide at a distance of about 3·5 cms. from the anterior end, possesses three sets of genitalia. The anteriormost and the middle one possesses reversed genitalia.

4. Still another proglottid of the above individual (Fig. 6), 1·40 mm. wide at a distance of 3·6 cms. from the anterior end shows two sets of almost mirror opposite genitalia. The posterior set being normal.

The vagina of both converge towards the common genital atrium. The cirrus sac, however, being single.

(B) The second individual shows the following aberrations :

5. It possesses a proglottid (Fig. 7) at a distance of 2 cms. from the anterior end, that shows four sets of genitalia. These sets being grouped in pairs, each with a single genital opening. The anterior pair with reversed female genitalia. The testes of the anterior set, of the anterior pair, are situated anterolaterally while those of the posterior set being lateral to the female genitalia. The anterior set of the posterior pair is reversed, the vitelline glands being located anterior to the ovary and the testes are laterally placed. The posterior set is normal and mirror opposite to the anterior. The two vaginae of the two sets of the anterior pair unite to form a common vagina that open in the genital atrium. The vaginae of the two sets of the posterior pair of genitalia open separately in the genital atrium. The cirrus sac opening in the anterior genital opening being single while that opening in the posterior being bifid.

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ABBREVIATIONS

c.s., cirrus sac ; g.a., genital atrium ; m.g., mehlis gland : o., ovary ; t., testes ; v., vagina ; v.g., vitelline gland ; v.c.v., ventral excretory vessel.

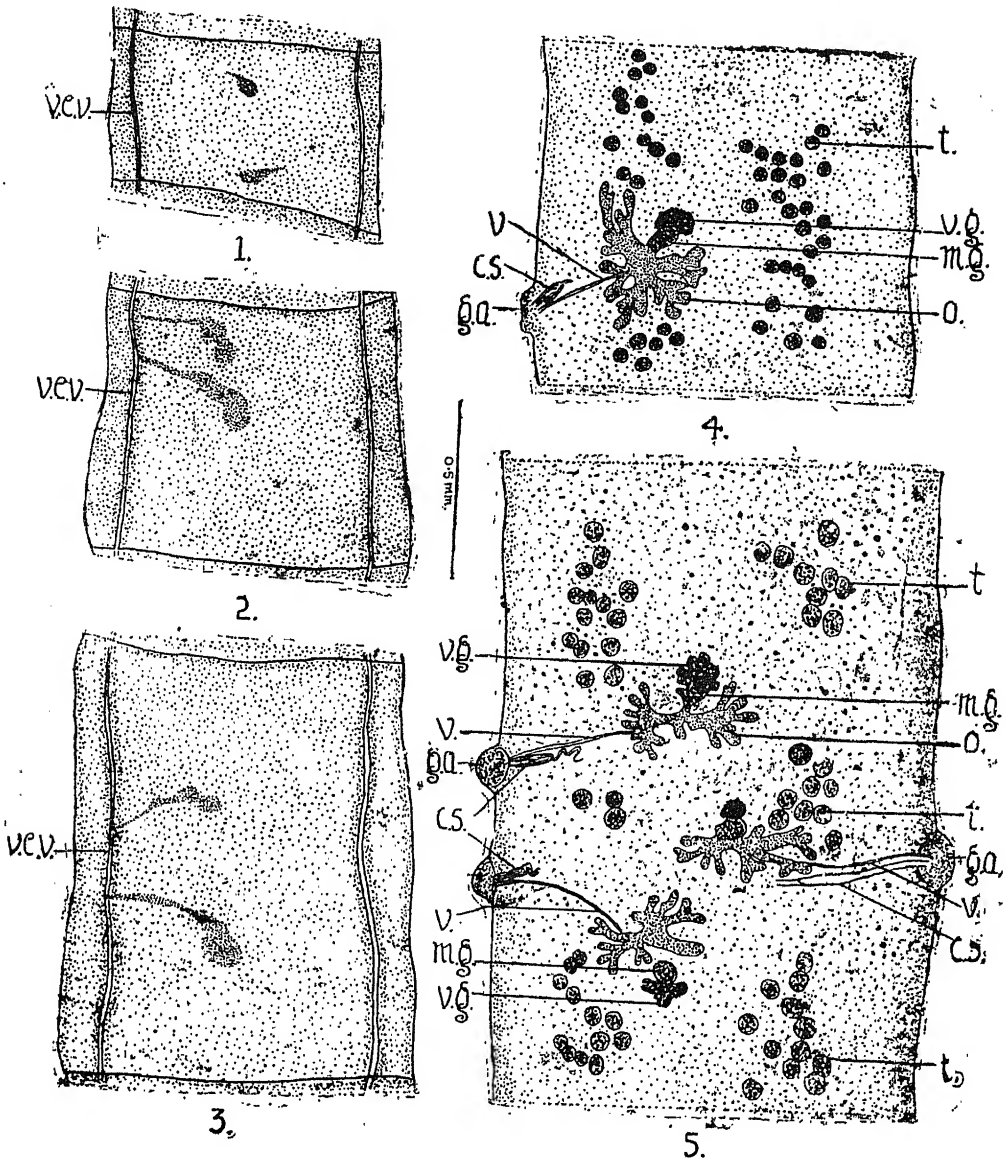

PLATE 1.

Fig. 1. Immature proglottid with two premordia × 18
Fig. 2. Immature proglottid with two premordia × 18
Fig. 3. Immature proglottid with two premordia × 18
Fig. 4. Mature proglottid with reversed female genitalia showing anterior, lateral and posterior testes × 18
Fig. 5. Mature proglottid with three sets of genitalia × 18

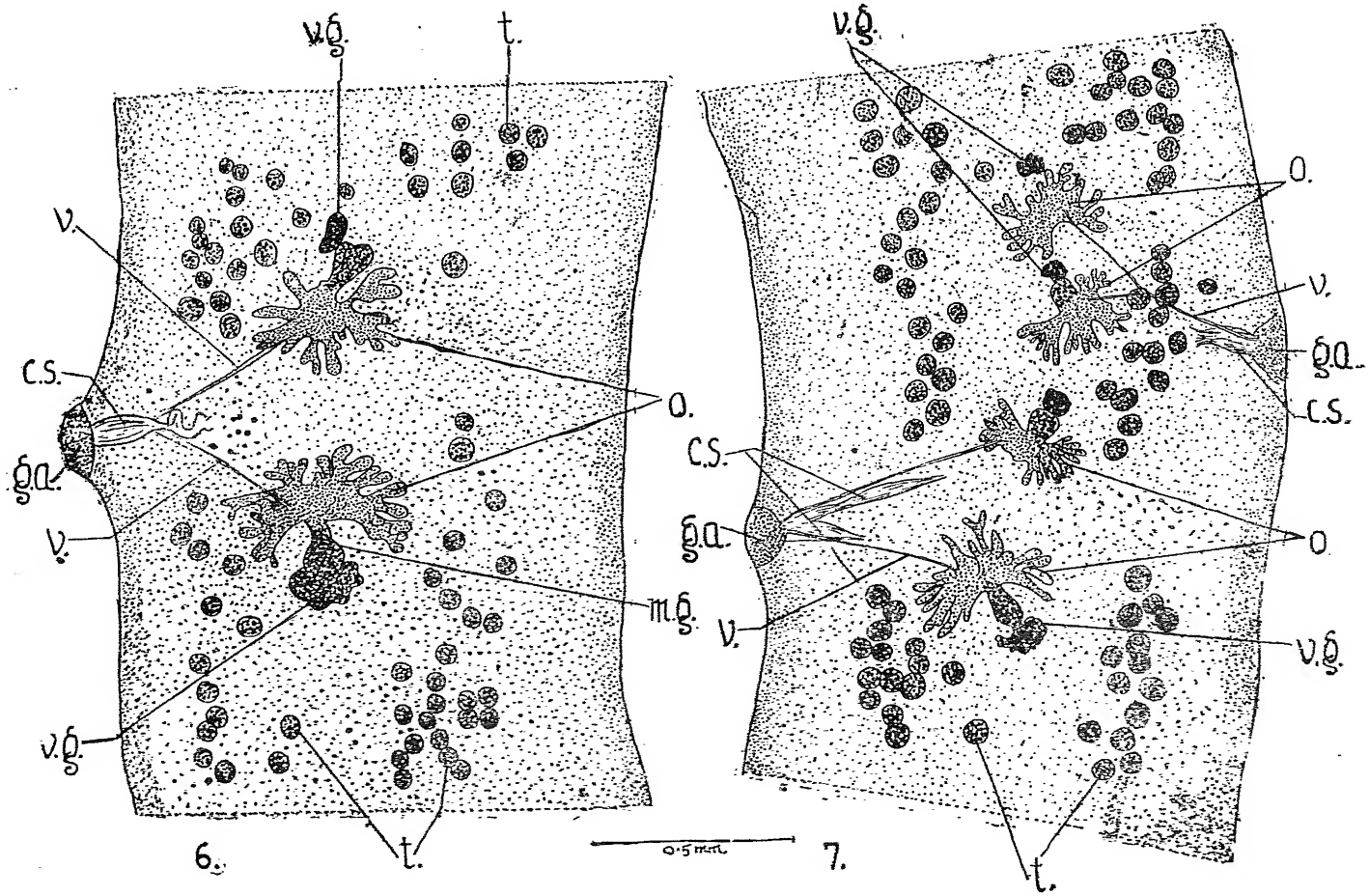

PLATE 2. Fig. 6. Mature proglottid with two sets of genitalia ×18
Fig. 7. Mature proglottid with four sets of genitalia ×18

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Variations in the morphology of the fruiting pustules of *Pestalotiopsis*

By

K. S. BILGRAMI & D. K. PUROHIT

Department of Botany, University of Jodhpur, Jodhpur

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Genus *Pestalotiopsis* was created by Steyaert in 1949, because he considered that the structure of the fruiting pustules in most of the species which were earlier attributed to the genus *Pestalotia*, was different from the typical cup like fruiting body of *P. pezizoides*-type species of *Pestalotia*. Dube and Bilgrami (1966) undertook detailed study on the comparative morphology of the fruiting pustules of *Pestalotiopsis*. Significant variations from a typical pycnidium to a typical acervulus have been recorded in this genus. In the present investigation the structure of the fruiting pustules of six different species of *Pestalotiopsis* viz. *Pestalotiopsis* sp., *P. royenae*, *P. paeoniae*, *P. theae*, *P. adusta* and *P. versicolor*, produced on *Berberis asiatica*, *Butea monosperma*, *Syzygium cumini*, *Rhododendron arboreum*, *Rhus mysorensis* and *Ziziphus jujuba* respectively, has been studied in detail. The main aim of these studies was to record the range of variation in the morphology of fruiting pustules of these interesting fungi because this aspect (structure of the fruiting bodies) rather than the conidial type has been responsible for creation of several genera in the Melanconiales and Sphaeropsidales having identical conidial morphology.

Materials and Methods

The infected leaves of *Berberis asiatica* Roxb., *Butea monosperma* (Lam.) Kuntz, *Syzygium cumini* (Linn.) Sheel, *Rhododendron arboreum* Sm., *Rhus mysorensis* Heyne and *Zizyphus jujuba* Lam., which had developed abundant fruiting bodies, were selected for the present comparative studies. Methods for the preservation dehydration and the preparation of the paraffin blocks were similar to those used by Dube and Bilgrami (1966). Microtome sections were cut at 12μ and canada balsam was used for the mounting of permanent slides.

Observations

Hosts marked* are new records. There was a pronounced variation in the morphology of fruiting structures produced on six different hosts.

1. **Berberis asiatica* Roxb.

Fruiting pustules completely embedded, epiphyllous, flattened-discoid to lenticular in shape. Acervulus with a multilayered stromatic wall, 109–127 × 189–203μ in dimensions, filled with numerous light coloured conidia, borne over short conidiophores.

2. *Butea monosperma* (Lam.) Kuntz

Two types of fruiting bodies were observed on this host : (*i*) A typically conical acervulues measuring 32–59 × 108–148μ, with 2–3 layered wall, pustules

compeletely packed with dark conidia developed on the small conidiophores. (*ii*) acervulus flat disc-shaped, with 2-3 layered wall, 35-54 × 162-203μ in dimensions. Both these types were subepidermal and produced on the upper surface of the host (Vide Plate 1, Fig. 1).

3. *Syzygium cumini* (Linn.) Sheel—*Eugenia jambolana* Lam.

Two different types of fruiting structures were produced on this host : (*i*) A typical oval to spherical pycnidium ranging from 68-109 × 108-162μ, with 4-8 layered thick pseudoparenchymatous wall, pustules completely embedded, epiphyllous with the numerous conidia produced at the tips of small conidiophores. (*ii*) A typical cup shaped partially embedded acervulus, measuring 81-100 × 127-181μ. Fructifications amphigenous with 2-4 layered wall, filled with numerous dark conidia borne on the short conidiophores.

4. *Rhododendron arboreum* Sm.

Fruiting bodies superficial, epiphyllous, borne over the epidermal layer with a very thin delicate wall, measuring 27-41 × 81-103μ, containing few dark 5-celled conidia.

5. **Rhus mysorensis* Heyne.

On this host three different types of acervuli were produced : (*i*) A conical, epiphyllous, subepidermal acervulus with pointed tip, measuring 81-108 × 135-149μ, with 4-5 layered wall, containing large number of conidia, produced on small conidiophores (Vide Plate 1, Fig. 2A). (*ii*) A typically conic, amphigenous, subepidermal, acervulus with 3-5 layered wall, size ranging from 30-68 × 100-140μ, filled with a large number of dark conidia produced on short conidiophores (Vide Plate 1, Fig. 2B). (*iii*) A flattened disc-shaped, epiphyllous acervulus with 5-6 layered stromatic wall. The dimension of pustules measured from 54-81 × 135-216μ, numerous conidia borne over small conidiophores (Vide Plate 1, Fig. 2C).

6. **Zizyphus jujuba* Lam.

Three different kinds of fruiting pustules were produced on this host also : (*i*) Conical acervuli, subepidermal, epiphyllous, with 3-5 layered wall, measuring 49-68 × 217-235μ in size, filled with versicolorous conidia produced on short conidiophores (Vide Plate 1, Fig. 3A). (*ii*) A disc-shaped acervulus, subepidermal, epiphyllous, measuring 49-68 × 149-203μ, acervuli filled with numerous versicolorous conidia produced on very small conidiophores (Vide Plate 1, Fig. 3B). (*iii*) Fructifications flask shaped, amphigenous with 2-3 layered wall, size ranged from 48-81 × 108-148μ, acervuli packed with dark conidia produced at the tips of small conidiophores (Vide Plate 1, Fig. 3C).

Discussion

Diverse type of fruiting pustules have been reported in various isolates which have been attributed to *Pestalotia* or *Pestalotiopsis*. Wolf (1908) and Klebahn (1914) found true pycnidial structures while, Leininger (1911) obtained fructifications like pycnidia, acervuli on a loose pseudoparenchymatous stroma, acervuli covered by pseudoparenchyma and even conidia on mycelial threads on different media. Elenkin and Chi (1912) created the genus *Pseudopestalotia* on the basis of pseudopycnidial structure of fruiting pustules and placed it in Pseudosphaerioidaceae. Archer (1926) reported that the development of the fruiting bodies of *Pestalotia guepini* and *P. palmarum* in culture was similar to that in the genus *Sphaeropsis*. Steyaert (1949) observed that *Pestalota pezizoides* belonged to Discellaceae of the order Sphaeropsidales due to apothecioid fruiting pustules. Dube and Bilgrami (1966) reported that there was no consistency regarding the exact shape of fruiting pustules in genus *Pestalotiopsis* and reported different grades of

PLATE I

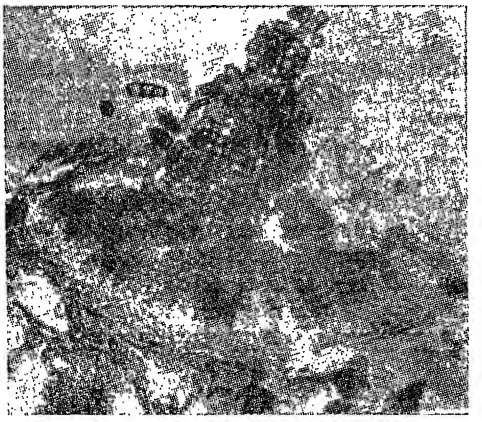

Fig. 2A. T. S. of leaf of *Rhus mysorensis* showing an acervulus with pointed tip of *Pestalotiopsis adusta*. (X625).

Fig. 2B. T. S. leaf of *Rhus mysorensis* showing a typically conic pustule of *P. adusta*. (X625).

Fig. 2C. T. S. of leaf of *Rhus mysorensis* showing a flattened disc-shaped pustule of *P. adusta*. (X162).

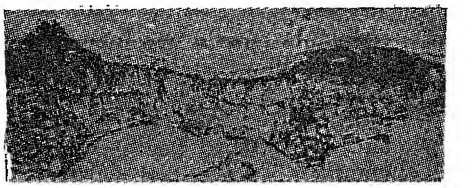

Fig. 1. T. S. of leaf of *Butea monosperma* showing two types of fruiting pustules of *Pestalotiopsis royenae*. (X137).

Fig. 3A. T. S. of leaf of *Zizyphus jujuba* showing a conical pustule of *Pestalotiopis versicolor*. (X394).

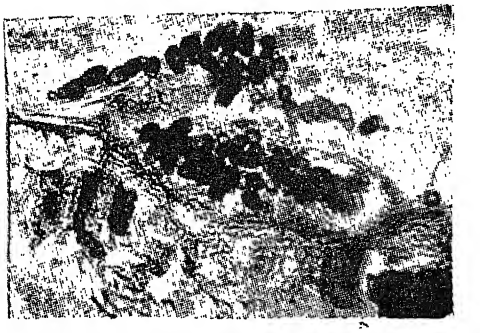

Fig. 3B. T. S. of leaf of *Zizyphus jujuba* showing a disc-shaped pustule of *Pestalotiopsis versicolor*. (X394).

Fig. 3C. T. S. of leaf of *Zizyphus jujuba* showing a flask shaped pustule of *Pestalotisopsis versicolor*. (X394).

variations from a typical acervulus to a typical pycnidium. The present investigations obviously indicate that in most of the cases fruiting bodies were usually subepidermal, in certain cases *e.g.* on *Rhododendron arboreum* they were superficial in nature. Dube and Bilgrami (1966) observed erumpent pycnidial, cushion like and disc-shaped pustules on *Syzygium cumini*. In addition to the above forms, completely embedded and typically cup shaped fruiting bodies were produced on this host. On *Butea monosperma*, conical and disc-shaped fructifications were produced on the same surface of the leaf. Besides these variations, the wall of the fruiting bodies showed great fluctuations in its thickness. Fruiting structures produced on *Rhododendron arboreum* had very thin delicate wall while the pustules on *Berberis asiatica* had stromatic wall. Different types of fruiting structures were produced by *Pestalotiopsis adusta* and *P. versicolor*, where the range of variation existed from a typical conic acervulus to a typical flask shaped structure. Earlier Dube and Bilgrami (1966) have reported the formation of a typical pycnidium in some species of *Pestalotia*. It is, therefore, evident that several species of *Pestalotia* and *Pestalotiopsis* show a transitional character between Sphaeropsidales and Melanconiales with regard to their fruiting pustule. It will therefore, be advantageous if the structure of the fruiting bodies of such species which have earlier been referred to *Monochaetia*, *Truncatella*, *Pestalotia* or *Pestalotiopsis* or other allied genera is studied in detail as these forms seem to link the typical Melanconiales and Sphaeropsidales.

Summary

A comparative study on the morphological variations in the fruiting pustules of six different species of *Pestalotiopsis* produced on six hosts viz. *Berberis asiatica*, *Butea monosperma*, *Rhododendron arboreum*, *Rhus mysorensis*, *Syzygium cumini* and *Zizyphus jujuba* was undertaken. On last three hosts, pycnidial as well as cup shaped, conical or flask shaped fruiting pustules were observed. On *Berberis asiatica* and *Rhododendron arboreum*, stromatic and thin walled fructifications were developed, while on *Butea monosperma* typically conical and disc-shaped acervuli were quite frequent on the same surface of the leaf.

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On some testacean rhizopods (Protozoa : Sarcodina) of the ground and tree mosses from Calcutta and its environs

By

K. N. NAIR & R. N. MUKHERJEE

Zoological Survey of India, Calcutta

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Introduction

The rhizopods inhabiting the mosses growing on wet and damp situations on the ground and the litchens on tree trunks from an interesting group of protozoa for study. They are cosmopolitan in their distribution and the forms encountered here are not very different from their counterparts known from the other countries. Our knowledge about this fauna occurring in the various parts of India is very scanty and an extensive survey is necessary. Penard (1907) reported fifteen species of rhizopods from the mosses gathered from Sikkim Himalayas. In this paper eleven species of rhizopods collected by the senior author from Calcutta and its near by two localities viz. Simurali and Gocharan during the monsoon period of 1967 (July-September) are recorded and the variations observed are noted.

Material and Methods

The mosses and litchens were brought to the laboratory and kept fresh for few days in petri-dishes by sprinkling just enough water daily on them. Drops were pipetted by capillary tubes and the specimens were observed in the living condition. Some of the isolated specimens were fixed in Schaudinn's fluid and stained either in Borax carmine or Heidenhain's iron-haematoxylin. The empty tests were air-dried after three or four washings in absolute alcohol and mounted in canada balsam. To avoid crushing of the delicate tests tiny pieces of cover slip were placed in the mounting medium to support the cover slip. All the measurements were taken with the aid of a calibrated ocular micrometer.

Systematic enumeration

Family : Gromiidae Eimer and Fickert

Genus : *Lieberkuhnia* Claparède and Lachmann

1. *Lieberkuhnia paludosa* (Cienkowsky) (Fig. 1)

L. paludosa (Cienkowsky), Penard, 1907, pp. 226–250, Figs. 1-14.

The shape of the test, the texture of test membrane, nature of plasma and the pseudopodial net-work are very similar to the descriptions of this species by Penard (1907). This species reported as an exclusively fresh water form displays considerable variations in its shape and size. The specimens observed here are sac-like, smaller in size measuring 188 × 66μ than the ones recorded by Penard (200–350μ). The extruded plasma is not seen investing the test at anytime.

The membrane is of uniform thickness throughout its length unlike the thicker membranous part in the anterior region shown in the figures by Penard (1907).

The primary contractile vacuole located at the base of the peduncle is followed by three small accessory vacuoles arranged very close to each other.

Habitat : Among the ground moss ; rare

Locality : Calcutta.

Family : Arcellidae Schultze

Genus : *Diplochlamys* Greeff

2. *Diplochlamys leidyi* Greeff (Figs. 2 and 3)

D. leidyi Greeff, Kudo, 1966, pp. 576–577, Fig. 205, i.

Test consists of two membranes ; the outer one hemispherical ; more rigid than the inner one, brown, surface rough due to the presence of various types of silicious and earthy particles encrusted on it, pieces of vegetable particles adhering to it. The inner membrane is delicate, grey, diaphanous, inverted funnel-shaped in the distented condition.

Aperture of outer membrane is circular, and that of inner membrane is oviform with a neck-like constriction below and a slightly expanded collar above. Six to eight minute pores are seen on the inner membrane just below the constriction.

The shape and nature of the test are very similar to those of Brown's figure of *D. leidyi* reproduced in Kudo (1966).

The possession of pores and a neck-like constriction are two very distinctive characters observed in the local specimens.

Size : Height of the test	...	... 82·5μ
Diameter ..	...	... 89–99μ
Aperture diameter	...	... 27μ
Size of a pore	...	... 1–1·5μ

Habitat : Among the mosses inter mixed with litchens on Banyan tree

Locality : Calcutta

Family : Difflugiidae Taránek

Genus : *Difflugia* Leclerc

3. *Difflugia globulus* (Ehrenberg), (Fig. 4)

D. globulus (Ehrenberg), Cash, 1909, **2**, pp. 33, 37 pl. 21, Figs. 5–9.

Test hemispherical, grey to pale yellow with few brown particles ; aperture round.

Size : Diameter	...	...	... 79–89μ
Aperture	...		... 25–33μ

Habitat : Among the ground moss

Locality : Calcutta

Genus : *Centropyxis* Stein

ABBREVIATIONS

Ap.—aperture ; As—Scales bordering aperture : Av—Accessory vacuole ; Bp—Brown particle ; C—Collar ; Cm—Process of chitinous membrane ; Ct—Thick cement : Cv—Contractile vacuole ; Dp—Denticulate projection ; Em—Encrusted matter ; Im—Internal membrane ; Nc—Neck ; Nu—Nucleus ; Om—Outer membrane ; P—Pore ; Pe—Peduncle ; Ps—Pseudopodium ; Rp—Reserve scales ; S—Amorphous scales ; Sb—Serrated border ; Tm—Test membrane ; Ts—Scales of test ; Vd—Ventral depression ; Vp—Vegetable particle.

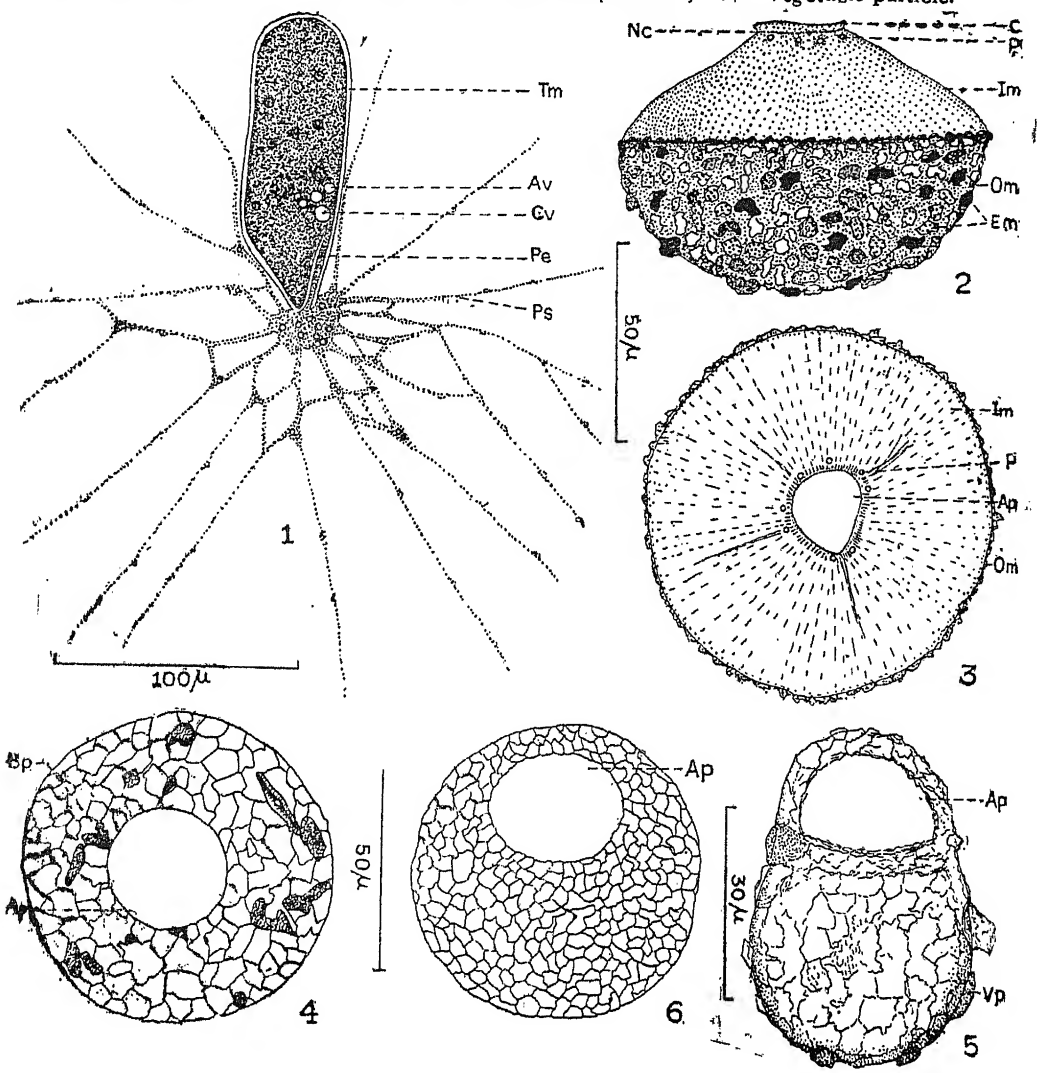
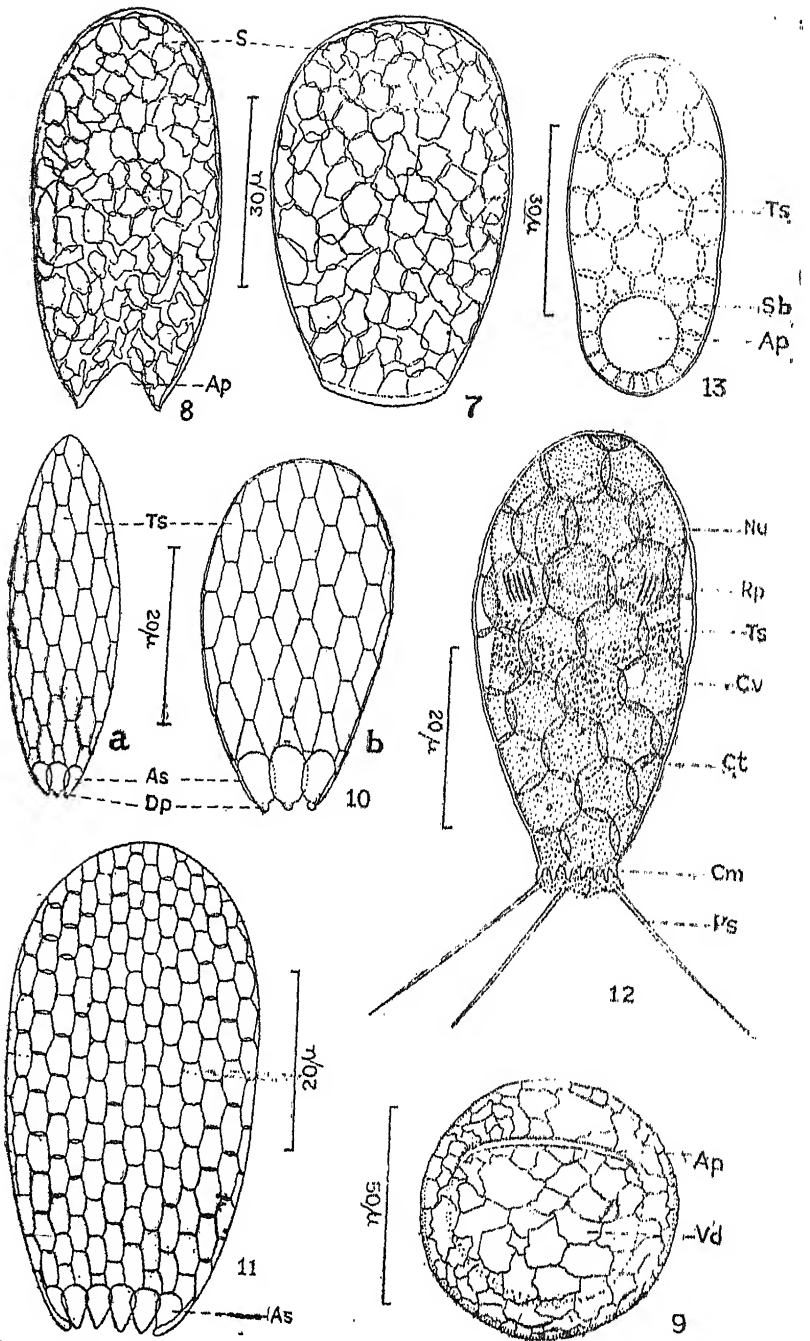


Fig. 1. *Lieberkuhnia paludosa* (Cienkowsky) (Active individual ; semidiagrammatic).
Figs. 2 & 3. *Diplochlamys leidyi* Greeff (Test. 2-lateral view, 3-apertural view).
Fig. 4. *Difflugia globulosa* (Ehrenberg) (Test, apertural view).
Fig. 5. *Centropyxis aerophila* Deflandre (Test, apertural view).
Fig. 6. *Centropyxis minuta* Deflandre (Test, apertural view).



Figs. 7. & 8. *Heleopera sylvatica* Penard (Test, 7–Broad side view ; 8–Narrow side view).
Fig. 9. *Plagiopyxis callida* Penard (Test, apertural view).
Figs. 10*a*. & 10*b*. *Euglypha rotunda* Wailes (Test, *a*-Narrow side view ; *b*-Broad side view).
Fig. 11. *Euglypha laevis* (Ehrenberg) (Test, Broad side view).
Fig. 12. *Trachelcuglypha dentata* (Vejdovsky) (Active individual ; lateral view).
Fig. 13. *Trinema enchelys* (Ehrenberg) (Test, apertural view).

4. *Centropyxis aerophila* Deflandre (Fig. 5).

C. aerophila Deflandre, 1929, **67**, pp. 330-332, Figs. 11–21.

Test with a spheroidal posterior portion, surface fibrous in texture with vegetable fragments and transparent crystals adhering to it. Aperture semi-circular.

The local specimens very closely resemble the forms described by Deflandre (1929) under the variety *sylvatica* in shape and texture.

Size : Length	... ...	... 59-69μ
Breadth	... ...	... 39-49μ
Aperture	... ...	... 16 × 9μ

Habitat : Among the tree moss mixed with litchen

Locality : Gocharan (Dist. 24 Parganas)

5. *Centropyxis minuta* Deflandre (Fig. 6)

C. minuta Deflandre, 1929, **67**, pp. 366–367, Figs. 148–152.

Test sub-spherical in lateral view, circular in ventral view with an eccentrically located round aperture.

Size : Diameter	... ...	.. 66–76μ
Aperture diameter	...	... 30–33μ

Variations observed are in its larger size (Deflandre, 1929) 35/60μ and in having the test surface encrusted with more crystals.

Habitat : Among ground moss

Locality : Simurali (Dist. Nadia)

Genus : *Heleopera* Leidy

6. *Heleopera sylvatica* Penard (Figs. 7 and 8)

H. sylvatica Penard, Cash, 1909, **2**, pp. 136–137, pl. 29, Figs. 10-12.

Test membrane transparent, with small scales of varied sizes and shapes on its surface.

Test oval in broad view, compressed with smooth crown and sides.

Mouth is convex with a narrow border devoid of scales, notched in its lateral view.

Plasma is hour-glass shaped, granular and putting forth 2 to 3 pseudopodia occasionally.

Size : Length	.. ...	... 59–70μ
Breadth	... ..	... 33-39μ
Thickness	.. ...	... 18–25μ
Aperture	... ...	... 16 × 12 × 6μ

The specimens observed are broader than the ones recorded by Cash (1909) 25–30μ. The crown is smooth unlike the ones shown in the figures of the species by Cash. The scales overlap each other slightly on their edges in the majority of the examples examined.

Habitat : Among the tree moss mixed with litchens

Locality : Gocharan (Dist. 24 Parganas)

Genus : *Plagiopyxis* Penard

7. *Plagiopyxis callida* Penard (Fig. 9)

P. callida Penard; Cash and Wailes, 1919, **4**, pp. 46-47, pl. 61, Fig. 7.

Test broadly hemispherical to ovoid in shape with a shallow depression on the ventral side. Aperture long, narrow with a concave upper lip and a more or less straight lower lip.

Size : Diameter	... ...	... 55–63μ
Length of aperture	...	... 30–32μ
Breadth of aperture	...	... 3·5–4μ

The specimens examined are small with camparitively bigger quartz crystals encrusting on it. The pseudopodia are not seen.

Habitat : Among ground moss

Locality : Calcutta and Simurali (Dist. Nadia)

Family : Euglyphidae Wallich.

Genus : *Euglypha* Dujardin

8. *Euglypha rotunda* Wailes (Figs. 10*a* and 10*b*)

E. rotunda Wailes, Decloitre, 1962, **106**, pp. 79–80, Figs. 60–63.

Test hyaline, compressed, medium size, imbrication of the test scales displaying hexagonal pattern on the surface. Aperture circular with eight oval scales, having a semicircular denticulate projection in each, bordering it.

Size : Length	... ...	... 32–39μ
Breadth	... ...	... 21–23μ
Thickness	... ...	... 16–17·5μ
Aperture	... ...	... 7–8μ in diameter

The specimens observed here are of medium size when compared with the dimension of the species given by Decloitre (1962).

Habitat : Among ground moss

Locality : Calcutta.

9. *Euglypha loevis* (Ehrenberg) (Fig. 11)

E. loevis (Ehrenberg) Perty. Decloitre, 1962, **106**, pp. 88–90, Figs. 82–83.

Test oviform, hyaline, moderately compressed, imbrication of the scales of test displaying a scalleriform pattern with number of rows on each side. Aperture circular bordered by ten pointed scales.

Size : Length	... ...	... 53–59μ
Breadth	... ...	... 26–33μ
Thickness	... ...	... 19-27μ
Aperture	... ...	. 6–14μ

The plasma protrudes out as a bulbous projection from which long, filose pseudopodia take their origin. The specimens observed are of medium size when compared to the dimensions given by Decloitre (1962). The apical scales are very prominent because of their extra thickness, wider gap in between their free ends and pale brownish tinge at their tips.

Habitat : Among ground moss

Locality : Calcutta

Genus : *Tracheleuglypha* Deflandre

10. *Tracheleuglypha dentata* (Vejdovsky) (Fig. 12)

T. dentata (Vejdovsky). Deflandre, 1953, p. 133, Fig. 94 G.

Test oval, hyaline ; test scales circular, the overlapping edges of the test scales very prominent due to the extra thickness of the cement.

Aperture circular, bordered by delicate, transparent chitinous membrane drawn out into finger-shaped processes.

The plasma in certain specimens is hour-glass shaped with a prominent spherical nucleus in the posterior part. The reserve scales secreted inside the plasma are seen arranged into two bundles on either sides of the base of the nucleus.

Size : Length	... ...	... 49–57μ
Breadth	... ..	... 23–26μ
Aperture	... ...	... 9–12μ
Diameter of scale	..	... 5–6μ

The specimens studied have the processes of the apertural membrane more of a finger-shaped nature than the acuminated tips shown in the figure by Deflandre (1953).

Habitat : Among the ground moss

Locality : Calcutta

Genus : *Trinema* Dujardin

11. *Trinema enchelys* (Ehrenberg) (Fig. 13)

T. enchelys (Ehrenberg), Kudo, 1966, p. 584, Fig. 209 *a*.

Typical specimens with a circular aperture placed sub-terminally on the compressed anterior part. Test scales circular and well imbricated. Border of aperture feebly serrated.

Size : Length	... ...	... 49–52μ
Breadth	... ...	... 23–25μ
Thickness	... ...	... 20–22μ
Aperture	... ...	... 13–15μ

The specimens observed are of medium size.

Habitat : Among the ground moss and tree moss.

Locality : Calcutta, Simurali and Gocharan.

Conclusions

Empty test of the testacean rhizopods are very commonly met with in abundance in this type of habitat more than the living ones. The main reason for this feature is that these animals have to depend mainly on the rain water and dew for their survival.

As stated elsewhere, the forms met with here are not very different from the ones reported from other countries.

Excepting the two species *viz. Trinema enchelys* (Ehrenberg) and *Difflugia globulus* (Ehrenberg), all the other nine species are recorded for the first time from India.

The four genera *viz. Lieberkuhnia* Claparéde and Lachmann, *Plagiopyxis* Penard, *Tracheleuglypha* Deflandre, and *Diplochlamys* Greeff are being recorded for the first time from India.

Summary

Eleven species of testacean rhizopods belonging to nine genera and four families collected from the ground moss and tree moss mixed with litchens from Calcutta and its nearby two localities *viz.* Simurali and Gocharan are reported in this paper. The prominent variations observed when compared with the findings of earlier workers are only noted. Nine species and four genera are being recorded for the first time from India.

Acknowledgement

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Some aspects of Vindhyans near Osian district Jodhpur. Rajasthan (India)

By

V. K. VERMA

Department of Geology, University of Delhi, Delhi–7

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The Vindhyan formations of India of Purana era (probably of Algonkian times extending even upto early Palaeozoic) derive the name from the great Vindhya mountain in Central India. The main outcrops of these sediments lie to the east of Aravalli range. However, a group of rocks of the "supposed Vindhyan system" occurs to the west of the Aravalli range as well.

The Vindhyans of the Western Rajasthan occur as detached tongue shaped outcrops with the apex towards north. Of the two, the western limb trends NE-SW and the eastern, roughly to the NNE-SSW. Besides, there are two isolated groups of outcrops : (*i*) occupying the area between Pokaran, Phalodi and Osian and (*ii*) the other at Khatu. The intervening area between the two limbs, as also between the detached outcrops, is blanketed by sand-sheets which occasionally accumulates by piling up into dunes—generally of oblique to transverse type.

Heron (1932)[1], carried out detailed field work and mapped the area. Besides him the area has been visited by Blanford[2], La Touche[3], Hacket[4], and Vredenburg[5] in the past. Except for Heron's work there seems to be no other notable publication on the Vindhyans of Western Rajasthan. These sedimentaries therefore require more attention than it received hitherto for manifold reasons.

The present paper embodies sedimentological studies based on field observations on the Vindhyan rocks at one such locality, falling in Survey of India Toposheet 45 B/NE namely Osian (Lat. N72°55'30" Long. E. 26°43'30") which lies about 65 km. north of Jodhpur, and can be approached both by rail and road. The entire area is covered with sands through which project out the Vindhyan outcrops as outliers. Further these outcrops often show examples of such features like mesa and butte which are typical of arid country. Butte is rather rarely seen and amongst the two when they occur together, mesa occupies an upper position.

Geology of the Area :

The base rock on which the sedimentaries have been deposited is not visible in the area. The red sandstone belonging to the upper Vindhyans, comprising the hills and ranges, is the lowest horizon met in this area. The base on which these sediments were laid down is however, not met with which may be because they have been concealed below the dunes and sheet sands. This sandstone is medium to fine grained, highly ferruginous and which at times has become soft due to partial leaching of the cementing material. As a sequel to this, the sandstones have attained higher degree of porosity. The thickness of the sandstone close to the railway track south of Osian railway station may be roughly 40–50 ft. In between, band of siltstone about a foot thick is present.

Overlying the sandstone, is a horizon of grit. It is made up of heterogeneous material exhibiting bimodality if not polymodality. The rock consists of quartz grains of 0·2″ while the maximum size does not exceed 0·3″. Quartz pebbles of about 1·0″ size are observed towards the top. The distribution of heavy minerals is not even in the grits and when present, they always occur as streak parallel to the stratification. There is very little or no cementing material present and perhaps this is the reason for their relatively poorer colouration. The grits forming the entire hillocks NNW of Mataji Ka Mandir at Osian are comparatively less hard and have about a foot thick ferruginous shale containing white glistening specks of mica. This transition to shale is gradual and imperceptible.

The change from sandstone to grit indicates a temporary discontinuity in the sedimentation process. Further, there is a parallelism maintained by the ovarlying grits with the underlying sandstone. In addition, there is also absence of any conspicuous wavy junction between the two horizons.

Stratigraphically, the youngest formation in the area is sheet sands and sand dunes. These are wind blown sediments as evidenced by the presence of small shells of gastropods in them which must have been blown from the western sea-coast.

Within the low-lying tract, about ½ mile N 25°W of Mataji Ka Mandir, in a small pocket of fine grained sandstone, about 6 ft. thick Kankar occurs. The formation of this appears to be due to local calcification of the sandstone. What could be the ultimate source of calcium is not clear as nowhere in the vicinity any lime bearing horizon is met.

The structure of the area is simple and it appears to be free from any major tectonic disturbance. The beds-fine sandstone as well as the grits, show a low dip of about 4° towards NE. The most prominent structural feature of the area is jointing. There are two sets of joints. The major joints run parallel to the dip direction, *i.e.* they trend NE–SW, and the other, minor set meets the former at an oblique angle. These are open joints and yield rhomb shaped blocks. The opening which is at times over 1½′ wide, is often filled by hard ferruginous shaly or silty material. The sandstone also shows a similar joint pattern. But the jointed blocks of the grits are bigger than those of sandstone.

Some Sedimentary Structural and Weathering products :

These sedimentary formations arouse interest because they contain unusual markings and structures which may be (*i*) inorganic or (*ii*) organic in nature :

Inorganic

The inorganic features of the area may be grouped into :

(*a*) current bedding,

(*b*) structures due to weathering.

(*a*) *Current bedding.*—Both the sandstone as well the grits are current bedded, the latter relatively more profusely. These structures are easily discernable in the grit, but in sandstone it is noticed only on closer examination along the quarry faces. Due to weathering they have become blurred and no detailed measurements could be made. However, the structure on the coarser material is much larger than that impressed on the fine sandstone. The current bedding shows truncated tops and asymptotic bottoms, (in the case of grits instances of bottom meeting at high angles indicative of torrential type are also not uncommon). The beds are, therefore, right-side-up. The top-set and bottom-set beds are in general parallel to each other.

No ripple marks were observed in the area.

(*b*) *Structures due to weathering.*—As a result of weathering, more or less a flat top is commonly seen in this area, accompanied with somewhat broader bottom connected through steps. These steps imparting trap like structure, have been formed perhaps due to removal of joint-blocks.

Another interesting feature is the presence of club-shaped small protruding structures rising about 0·25″ to 0·5″ above the surface. The head is a well rounded knob with a maximum diameter of 0 75″ approx. connected with the bed through a short slender neck. In many cases the head is highly spherical. These are observed on the sandstone. The compositional material of the knob and its base is apparently the same. Perhaps strong binding caused their escape from erosion, due to atmospheric agencies.

Another feature of weathering is as shown in Plate I-A. The hand specimen is collected from the grits consisting of medium to fine grains, some even as coarse as 0·1″ diameter with very little or without cementing material. This feature is perhaps due to the action of percolating water causing the removal of ferruginous cementing material which has also rendered the rock more or less colourless.

Somewhat hard, equigranular fine grained sandstone shows enormous small holes of size, 1/16th of an inch or even less (Plate I-B). They have generally smooth, circular to elliptical outline. Such holes profusely occur both on weathered and fresh surfaces. On fresh surface the holes show some black enerustation, which may perhaps be due to carbon. This feature appears to be not due to weathering as is evidenced by the smooth outline. It may have been formed due to impairment of packing of grains before final compaction, by the evolution of gases from decomposing organic matter. This needs further verification. Alternatively such an inorganic process is to be thought of, by which the soluble grains are so clearly removed, if the process involved is chemical, or mechanical detachment is so smooth that the surrounding is still devoid of roughing the neighbouring surface on weathering. This is rather unusual. These holes, therefore, may be gas pits (?).

Organic

The Vindhyans rocks, hitherto, were supposed to be completely devoid of any fossil records. In recent years discoveries of presence of life in Vindhyans from its eastern extensions have been reported by several workers. However, the only organic occurrence known from these formations of Western Rajasthan is that of algal stromatolites from Bilara limestone by Khilnani (1964)[6], besides chardophyceous tracks in sandstones from this locality itself, recorded and figured by Vredenburg (1908)[5].

A search for fossil tracks of chardophyceae failed to register any record from this area in the present survey. However, during the current studies organic structures of doubtful origin have been recorded from the siltstone occurring in the sandstone horizon.

(*a*) *Algal structures*

Some structures perhaps due to algae appear to have been preserved. They are calcareous in nature but entombed in arenaceous rocks. There is a great resemblance between these structures and the those cited by Pettijohn (1957)[7]. They occur like small beads as may be seen in the upper right side of Plate I-C. Plate I-D shows a polished transverse section of such a structure. The irregular

light-colour layer may be due to typical spongy alga (?) which alternates with the irregular dark layer of inorganic hematite. The internal structure is seen in the lower half of Plate I-C. These sections have been cut by the nature, most of them are longitudinal. Plate I-E shows such a section duly enlarged for details. They are trigonal, circular to elliptical in shape, elliptical ones are most common. The maximum size is approximately half an inch. In Plate I-C and I-E, the light coloured spongy algal deposit may be observed in contrast to dark dense inorganic layer. The beads themselves and in sections show perfect rounded outlines. Some sections of the beads were also prepared which look identical to those in Plate I-C above. Few small holes are seen near the right margin and towards the bottom of Plate I-C. These may be due to burrowing animals and parasites. A small pear-shaped body of size slightly greater than the rice grains is also observed (Plate I-F). It occurs in a shallow pit. When treated with a drop of dilute hydrochloric acid it gives off effervescence, whereas the host rock does not react.

(*b*) *Colonial Structures*

On breaking the rocks, some colonial structures are seen underneath on both surfaces. The width of the colonies vary from 0·2″ to about 1·0″. The larger ones may have been formed due to coalescing of smaller ones. They are circular to fusiform in outline, bordered with yellowish green colour, the central area being rather waxy. Plate II-A shows this structure. These structures are almost uniformly thick and are made up of carbonate matter within arenaceous environment. These may as well be the deformations produced by burrowing type of organism (Potter and Pettijohn)[9]. The specimen also shows the presence of some thin lenticular cavities, seen as dark spots in the Plate II-B, which are sometimes filled with secondary silica.

(*c*) *Shelly Material*

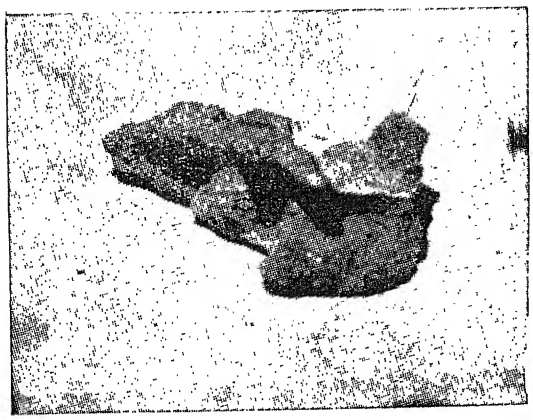
Fragments of shell-like horny structures (Plate II-C) made up of carbonate are found embedded in ferruginous siltstone. They are about half an inch in size. The specimens are too-ill preserved for generic determinations and appear to be valves of some primitive animals. On close examination, some lines transverse to the shell length may also be observed. Though, prevalent all over, these lines and the shell-line structures are better seen in the right half of the figure. These shelly materials are broken and do not give any idea of the umbo etc.

(*d*) *Bleach Blotches*

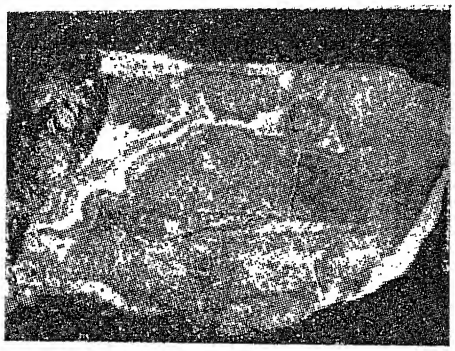
Pale to white circular, elliptical and fusiform bleach spots are quite common in some Vindhyan horizons. Though, these spots do not occur profusely in this area, they are not altogether absent. They are generally circular to elliptical in shape with well rounded smooth outline, and are of 1·0″ diameter. As usual, they are pale in colour. These bleach spots are perhaps due to reduction of ferric oxide to ferrous oxide around fragments of organic materials and subsequent removal of iron (Tyrrell 1948)[8]. This may, therefore, constitute an indirect evidence of the presence of life.

The organisms appear to be of soft nature which would yield to the pressure to which they may have been subjected and assume a shape-circular, elliptical or fusiform depending upon the nature of pressure. The fading away of the colour in the blotches, would have been gradual had it been due to chemical action alone and not sharp as in the present case.

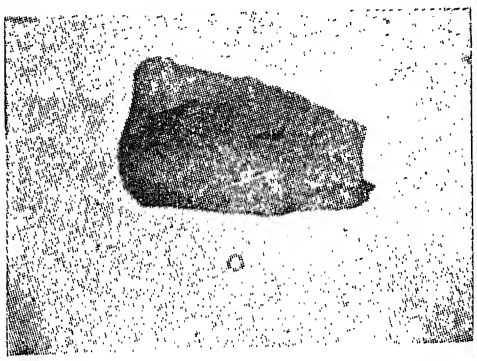
PLATE I



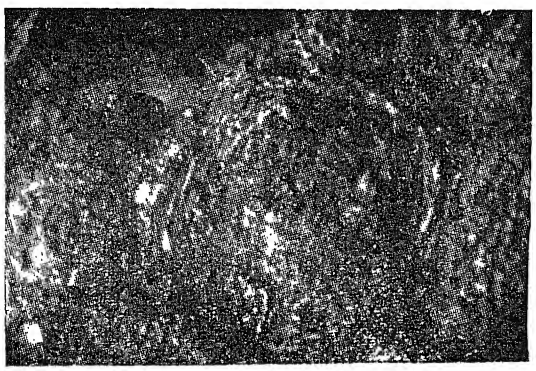
A. An unusual weathering feature.



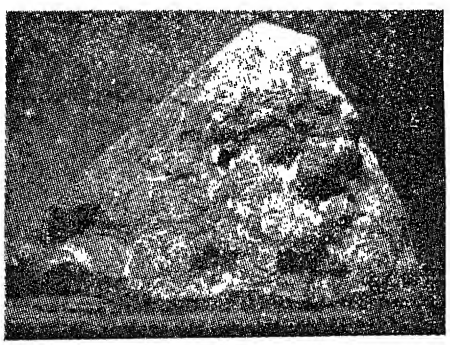
D. Polished transverse section of algal structure.



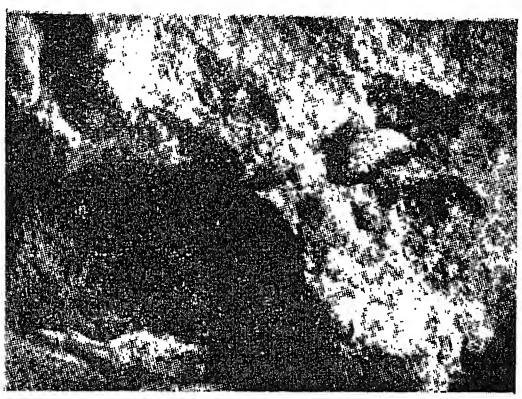
B. Gas pits (?) in sandstone.



E. Close-up of algal structure.

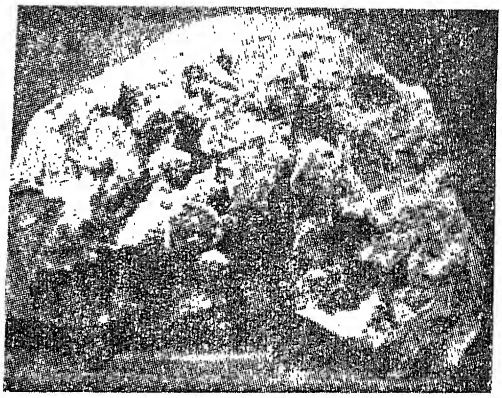


C. Algal structures (?) in siltstone.

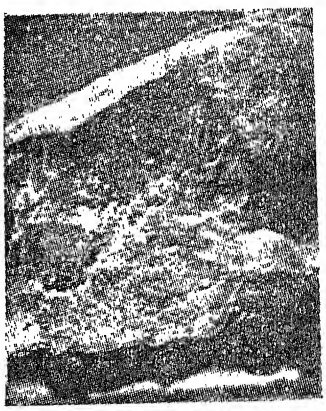


F. A pear-shaped calcareous body.

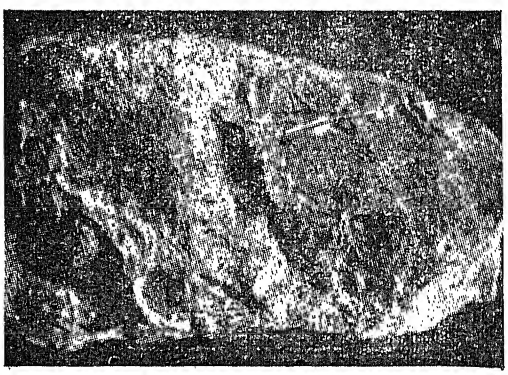
PLATE II



A. Colonial structure (?)



B. Thin lenticular cavities showing secondary silica.



C. Shelly material (?)

Pebble Fabric

At some places on the top of the grits some cavities are met which may have housed pebbles. They are generally smooth and equidimensional, a feature which indicates the possibility of rounded pebbles, perhaps water-worn. However, some elongate cavities are also present. The elongation directions of a few of them are as follows :

(*i*) NW-SE	(*ii*) N–S	(*iii*) N10°W-S10°E
(*iv*) N 35°E	(*v*) NNW-SSE	(*vi*) NE-SW
(*vii*) NW-SE	(*viii*) N-S	(*ix*) N-S
(*x*) N-S	(*xi*) N15°E	(*xii*) NNW-SSE
(*xiii*) N10°W-S10°E	(*xiv*) N12°W-S12°E	(*xv*) N20°W-S20°E
(*xvi*) NNW-SSE	(*xvii*) NNE-SSW	(*xviii*) NNW-SSE
(*xix*) N18°W-S18°E	(*xx*) NW-SE	(*xxi*) N35°W-S35°E
(*xxii*) N12°W-S12°E	(*xxiii*) NNW-SSE	(*xxiv*) NW-SE

A population of 88% indicates the current direction somewhere between NE-E and SW-W. This deduction is of emperical value only, because :

(*i*) it does not register the flow, whether it is NE-E to SW-W or *vice-versa*, and

(*ii*) the elongated pebbles themselves, the basis of the deduction, are quite few in contrast to equidimensional.

Conditions of deposition

On the basis of the present studies, it may be concluded that :

(*a*) the sediments seem to have been laid down under shallow water condition as is shown by the presence of current bedding.

(*b*) the basin was relatively shallowing with continued deposition, evidenced by coarser sedimentation towards the top with relatively larger current bedded structure.

(*c*) the presence of organic (?) structures indicate the prevalence of marine conditions, with water shallow enough to permit light penetration where algae and such other organisms could thrive.

(*d*) perhaps after the deposition ceased or when the beds were raised above, the area was subjected to intense atmospheric agencies which gave raise to peculiar products of weathering.

Correlation

A precise correlation of these sedimentaries with main Vindhyans basin is rather difficult. They differ from the Rewahs in not having the alternations of sandstones and shales. The Bhanders of the main Vindhyan basin are characterised by the presence :

(*i*) mature and fine grained sandstones.

(*ii*) white or pale specks or blotches in abundance.

(*iii*) imprints of ripple marks, and

(*iv*) gypsum along the planes of stratification.

Such features are quite uncommon in this area. In view of these, the present arenaceous formations may be tentatively fixed as equivalents of Kaimurs

on the basis of predominance of rock types and by the process of elimination. The only fact that goes against this postulate is that the sandstone is not as hard.

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Effect of Hormones on Microbial Population*

By

(KM.) S. GUJARATI

Department of Botany, Banaras Hindu University, Vasanasi-5

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Introduction

The study of growth substances has involved principally two major fields, viz. (*a*) the effect of auxins on higher plants and (*b*) the effect of accessory growth substances on micro-organisms. Until the present time, little effort has been made to correlate these two factors. Studies of the effect of growth-regulating substances on filamentous fungi were carried out by Bhargava (1946), Leonian (1938), Lionian and Lilly (1937) and Murdia (1939). They came to the conclusion that all higher concentrations of heteroauxins proved inhibitory or toxic, whereas the lower ones failed to induce stimulation. Ronsdorf (1935), using pure auxin 'a' with several filamentous fungi was unable to recover the auxin or to demonstrate its effect on the growth of fungi. Richard (1949) studied the effect of four growth-regulating substances, indole-3 acetic acid, alpha-naphthalene oxy-acetic acid on the linear growth, and spore germination of *Phycomyces blakesleanus*, *Aspergillus candidus*, *Neocosmospora tetrasperma* and *Schilzophyllum commune*. He noted that the effect of these substances on the above different fungi were of two types : stimulatory and inhibitory. Inhibition occurred within the concentration range of 10^{-2} to 10^{-3} molar and stimulation within the concentration range of 10^{-3} to 10^{-4} molar.

Since reports of the effects of growth-regulating substances on filamentous fungi have not been explicit, an attempt was made to investigate the effect of hormones either by the spray method or with seed treatment on the rhizosphere micro-flora of *Lens esculenta* Moench. Meth. and *Cicer arietinum* Linn.

Method

Seeds of the above two crops treated with hormones were sown in triplicate pots containing sterilized soil. The three concentrations, viz. 25–, 50– and 100–ppm. of I–indole acetic acid, II–indole–3yl–propionic acid, III–1–naphthoxy acetic acid and IV– 2 naphthoxy acetic acid were used. The seeds were kept for 8 hours in the above hormone solutions prepared in sterilized distilled water. The above seeds were then removed from the solution and dried on sterilized filter paper to remove the excess of the hormone solution adhering to the seeds. Untreated seeds, soaked in sterilized distilled water for 8 hours, were also sown in three pots to serve as the control. The pots were watered regularly with sterilized water.

In another set of the experiment, the untreated seeds of *Lens esculenta* and *Cicer arietinum* were sown in pots containing sterilized soil. The seedlings after 15 days of sowing were sprayed with the above-mentioned three concentrations of the four hormones. Spraying on foliage was done fortnightly with an atomizer. Care was taken to avoid the fall of drops of hormones on the surface of the soil,

*Part of the thesis approved for award of Ph.D. Degree of Banaras Hindu University.

and this was achieved by covering the surface with polythene covers. Unsprayed plants served as the control.

Fortnightly isolations of the rhizosphere microorganisms were made both in the case of hormone-treated plants and the control plants. The method followed was that the roots of the plants were shaken gently to remove extra soil and were then put into sterilized 250 cc. conical flasks containing 200 cc. of sterilized distilled water. The flasks were shaken to make a homogenous suspension of the adhering soil. One cc. of the solution was poured into 10 sterilized 90 mm. Petri-dishes for the isolation of fungi and into 5 plates for determining the number of bacterial colonies.

TABLE 1

Fungal species isolated from rhizosphere of Lens (L) and Gram (G).
(Seed treatment method)

Fungi	HORMONES							
	I		II		III		IV	
	L	G	L	G	L	G	L	G
Mucor hiemalis Wehmer	+	+	+	+	+	+	+	+
Rhizopus nigricans Ehrenberg	+	+	+	+	+	+	+	–
Cunninghamella blakesleeana Lendner	+	+	+	–	–	–	–	+
Syncephalastrum racemosum (Cohn' Schroeter	–	–	+	–	–	–	–	+
Thielavia terricola (Gilman and Abbott) Emmons	–	–	–	–	+	–	+	–
Aspergillus nidulans (Eidam) Wint	–	–	–	–	–	+	–	–
Phoma sp.	+	+	+	+	+	–	+	+
Trichoderma viride Pers. exFr.	+	+	+	+	+	+	+	+
Paecilomyces fusisporus Saks.	+	–	+	+	+	+	+	+
Aspergillus niger Van Tiegham	+	+	+	+	+	+	+	+
A. flavus Link	+	+	+	+	+	+	+	+
A. terreus Thom	+	+	+	+	+	+	+	+
A. sydowi (Bain. and Sar.) Thom and Church	–	–	–	–		+	–	–
Penicillium humicola Oud.	+	+	+	–	+	+	+	+
P. notatum Westling	+	+	+	+	+	–	+	–
Alternaria humicola Oud.	+	–	+	–	+	+	+	–
Humicola fusco-atra Traaen	–	–	–	–	-	–	+	–
Curvularia lunata (Walker) Beodijn	+	+	+	+	+	+	+	+
Cladosporium herbarum (Persoon) Link	+	+	+	+	+	+	+	+
Fusarium sp.	+	+	+	+	+	+	+	+
Myrothecium verrucaria (Albertini and Schweinitz) Ditmar	–	–	–	–	+	–	–	–
Selerotium sp.	–	–	–	+	–	–	–	–

+, Present, –, Absent.

TABLE II

Fungal species isolated from rhizospheres of Lens (L) and Gram (G) (Spray-method)

Fungi	HORMONES							
	I		II		III		IV	
	L	G	L	G	L	G	L	G
Mucor hiemalis Wehmer	+	+	+	–	+	–	+	+
Rhizopus nigricans Ehrenberg	+	+	+	+	+	+	+	+
Thielavia terricola (Gilman and Abbott) Emmons	–	–	+	–	+	–	+	–
Aspergillus nidulans (Eidam) Wint	–	–	+	–	–	–	–	–
Phoma hibernica Grimes, O'Connor and Cummins	+	–	+	+	+	+	+	+
Trichoderma viride Pers. exFr.	+	+	+	+	+	+	+	+
Paecilomyces fusisporus Saks.	+	+	+	+	+	+	+	+
P. varioti Bainier	–	–	+	–	–	–	–	–
Aspergillus niger Van Tiegham	+	+	+	+	+	+	+	+
A. flavus Link	+	+	+	+	+	+	+	+
A. terreus Thom	+	–	+	+	+	–	+	+
A. sydowi (Bain. and Sar.) Thom and Church	–	–	–	+	–	–	–	–
Penicillium humicola Oud.	+	+	+	–	+	–	+	+
P. notatum Westling	+	+	+	+	+	+	+	+
Cephalosporium asperum Marchal	+	–	+	–	–	–	–	–
Alternaria humicola Oud.	+	+	+	+	+	–	+	+
A. tenuis Nees	–	–	+	–	+	–	+	–
Curvularia lunata (Walker) Boedijn	+	+	+	–	+	+	+	–
Helminthosporium sp.	–	–	–	+	–	–	–	–
Hormiscium sp.	–	+	–	–	–	–	–	+
Fusarium sp.	+	+	+	+	+	+	+	+

+, Present –, Absent

TABLE III

Average number of bacetria/gm. dry soil in rhizosphere of Lens esculenta

Hormones		19 January, 1965		5 February, 1965		19 February, 1965		5 March, 1965		19 March, 1965		April, 1965
		ST	SP	ST	SP	ST	SP	ST	SP	ST	SP	SP
I. Indol acetic acid	25 ppm.	$19{\cdot}1 \times 10^3$	29×10^5	34×10^4	28×10^5	35×10^4	28×10^5	$37{\cdot}6 \times 10^3$	$36{\cdot}5 \times 10^4$	3×10^5	$35{\cdot}4 \times 10^4$	2×10^6
	50 ppm.	$91{\cdot}3 \times 10^3$	$34{\cdot}6 \times 10^4$	98×10^4	36×10^5	10^6	59×10^5	12×10^5	53×10^5	$90{\cdot}4 \times 10^3$	62×10^5	3×10^6
	100 ppm.	$32{\cdot}3 \times 10^3$	$21{\cdot}2 \times 10^4$	32×10^4	$21{\cdot}4 \times 10^4$	25×10^4	5×10^6	25×10^4	$43{\cdot}3 \times 10^4$	$20{\cdot}4 \times 10^3$	32×10^5	2×10^6
II. Indol-3yl Propionic acid	25 ppm.	2×10^5	$11{\cdot}5 \times 10^4$	6×10^5	$39{\cdot}7 \times 10^4$	75×10^4	$45{\cdot}3 \times 10$	79×10^4	$57{\cdot}5 \times 10^4$	74×10^4	$41{\cdot}4 \times 10^4$	$31{\cdot}3 \times 10^4$
	50 ppm.	$37{\cdot}8 \times 10^3$	$22{\cdot}1 \times 10^4$	8×10^5	36×10^5	$89{\cdot}3 \times 10^3$	47×10^5	9×10^5	$81{\cdot}4 \times 10^4$	$91{\cdot}2 \times 10^3$	$56{\cdot}5 \times 10^4$	4×10^6
	100 ppm.	$12{\cdot}9 \times 10^3$	$13{\cdot}1 \times 10^4$	$46{\cdot}7 \times 10^3$	$13{\cdot}7 \times 10^4$	$50{\cdot}1 \times 10^3$	$10{\cdot}1 \times 10^4$	65×10^4	$41{\cdot}5 \times 10^4$	$40{\cdot}3 \times 10^3$	44×10^5	$13{\cdot}5 \times 10^4$
III. 1-naphtha acetic acid	25 ppm.	3×10^5	$33{\cdot}5 \times 10^4$	5×10^5	$39{\cdot}6 \times 10^4$	$20{\cdot}5 \times 10^3$	$78{\cdot}6 \times 10^4$	$12{\cdot}5 \times 10^3$	77×10^5	10^5	32×10^5	4×10^6
	50 ppm.	34×10^4	53×10^5	$45{\cdot}1 \times 10^3$	$55{\cdot}6 \times 10^4$	$71{\cdot}7 \times 10^3$	$57{\cdot}2 \times 10^4$	62×10^4	$82{\cdot}5 \times 10^4$	$50{\cdot}3 \times 10^3$	$57{\cdot}5 \times 10^4$	3×10^6
	100 ppm.	$20{\cdot}8 \times 10^3$	$15{\cdot}5 \times 10^4$	3×10^5	$14{\cdot}3 \times 10^4$	$55{\cdot}5 \times 10^3$	$35{\cdot}2 \times 10^4$	23×10^4	$46{\cdot}2 \times 10^4$	11×10^4	33×10^5	$30{\cdot}3 \times 10^4$
IV. 2-naphtha acetic acid	25 ppm.	$40{\cdot}7 \times 10^3$	$34{\cdot}4 \times 10^4$	5×10^5	$36{\cdot}8 \times 10^4$	75×10^4	$32{\cdot}2 \times 10^4$	32×10^4	44×10^5	31×10^4	66×10^5	4×10^6
	50 ppm.	$68{\cdot}5 \times 10^3$	$33{\cdot}4 \times 10^4$	$90{\cdot}7 \times 10^3$	$50{\cdot}4 \times 10^4$	12×10^5	6×10^4	$10{\cdot}5 \times 10^4$	$63{\cdot}3 \times 10^4$	5×10^5	68×10^5	7×10^6
	100 ppm.	35×10^4	$13{\cdot}6 \times 10^4$	39×10^4	$27{\cdot}3 \times 10^4$	25×10^4	$28{\cdot}7 \times 10^4$	$50{\cdot}1 \times 10^3$	31×10^5	4×10^5	50×10^5	9×10^6
Control		$18{\cdot}7 \times 10^2$	$12{\cdot}2 \times 10^4$	2×10^5	$20{\cdot}6 \times 10^4$	30×10^4	$27{\cdot}6 \times 10^4$	25×10^4	$20{\cdot}9 \times 10^4$	15×10^4	$29{\cdot}6 \times 10^4$	$20{\cdot}8 \times 10^4$

ST. Seed treatment method.

SP. Sprayed method.

TABLE IV

Average number of bacteria/gm dry soil in rhizosphere of Cicer arietinum

Hormones		16th Jan., 1965		3rd Feb., 1965		16th Feb. 1965		3rd Mar. 1965		16th Mar. 1965		28th Mar. 1965
		ST	SP	ST	SP	ST	SP	ST	SP	ST	SP	SP
I. Indol–acetic acid	25 ppm.	28×10^4	$13{\cdot}1 \times 10^3$	$37{\cdot}4 \times 10^3$	$15{\cdot}4 \times 10^3$	$48{\cdot}6 \times 10^3$	14×10^4	75×10^4	5×10^5	7×10^5	35×10^4	25×10^4
	50 ppm.	$47{\cdot}4 \times 10^3$	37×10^4	5×10^5	$46{\cdot}5 \times 10^3$	$56{\cdot}3 \times 10^3$	$28{\cdot}3 \times 10^4$	$60{\cdot}3 \times 10^3$	88×10^4	$60{\cdot}1 \times 10^3$	89×10^4	75×10^4
	100 ppm.	$12{\cdot}9 \times 10^3$	$11{\cdot}3 \times 10^3$	$25{\cdot}4 \times 10^3$	$13{\cdot}1 \times 10^3$	$43{\cdot}3 \times 10^3$	$12{\cdot}5 \times 10^3$	4×10^5	35×10^4	35×10^4	4×10^5	$30{\cdot}1 \times 10^3$
II. Indol-3yl Propionic-acid	25 ppm.	$10{\cdot}7 \times 10^3$	4×10^5	$40{\cdot}9 \times 10^3$	$44{\cdot}3 \times 10^3$	$40{\cdot}7 \times 10^3$	56×10^4	$55{\cdot}4 \times 10^3$	$60{\cdot}3 \times 10^3$	4×10^5	5×10^5	35×10^4
	50 ppm.	$33{\cdot}3 \times 0^3$	69×10^4	$35{\cdot}2 \times 10^3$	63×10^4	$59{\cdot}3 \times 10^3$	69×10^4	$57{\cdot}3 \times 10^3$	$93{\cdot}2 \times 10^3$	$50{\cdot}6 \times 10^3$	10^5	$50{\cdot}3 \times 10^3$
	100 ppm.	$1 \cdot 4 \times 10^3$	53×10^4	$34{\cdot}7 \times 10^3$	$29{\cdot}6 \times 10^3$	$38{\cdot}9 \times 10^3$	38×10^4	$45{\cdot}7 \times 10^3$	$40{\cdot}3 \times 10^3$	25×10^4	$30{\cdot}4 \times 10^3$	4×10^5
III. 1-naphtha acetic acid	25 ppm.	$31{\cdot}5 \times 10^4$	14×10^4	$33{\cdot}5 \times 10^3$	$22{\cdot}1 \times 10^3$	$67{\cdot}8 \times 10^3$	$24{\cdot}3 \times 10^3$	$42{\cdot}7 \times 10^3$	$47{\cdot}5 \times 10^3$	42×10^4	$50{\cdot}6 \times 10^3$	$30{\cdot}6 \times 10^3$
	50 ppm.	52×10^4	$22{\cdot}9 \times 10^3$	$68{\cdot}3 \times 10^3$	$33{\cdot}5 \times 10^3$	$77{\cdot}5 \times 10^3$	58×10^4	$73{\cdot}3 \times 10^4$	59×10^4	7×10^5	53×10^4	39×10^4
	100 ppm.	$24{\cdot}5 \times 10^3$	15×10^4	57×10^3	16×10^4	$23{\cdot}4 \times 10^3$	20×10^4	42×10^4	35×10^4	$50{\cdot}4 \times 10^3$	39×10^4	$20{\cdot}1 \times 10^3$
IV. 2-naphtha acetic acid	25 ppm.	$26{\cdot}4 \times 10^3$	$63{\cdot}3 \times 10^3$	$47{\cdot}8 \times 10^3$	$69{\cdot}4 \times 10^3$	$46{\cdot}1 \times 10^3$	7×10^5	$54{\cdot}1 \times 10^3$	$48{\cdot}7 \times 10^3$	$30{\cdot}1 \times 10^3$	35×10^4	36×10^4
	50 ppm.	6×10^5	79×10^4	7×10^5	$80{\cdot}3 \times 10^3$	$90{\cdot}4 \times 10^3$	91×10^4	$75{\cdot}2 \times 10^3$	10^6	9×10^5	85×10^4	75×10^4
	100 ppm.	3×10^5	55×10^4	$31{\cdot}3 \times 10^3$	67×10^4	$55{\cdot}5 \times 10^3$	63×10^4	8×10^5	51×10^4	$25{\cdot}6 \times 10^3$	$14{\cdot}3 \times 10^3$	$25{\cdot}3 \times 10^3$
Control		$86{\cdot}4 \times 10^2$	$11{\cdot}4 \times 10^3$	$12{\cdot}6 \times 10^3$	$19{\cdot}1 \times 10^3$	$19{\cdot}6 \times 10^3$	$40{\cdot}6 \times 10^3$	$98{\cdot}6 \times 10^3$	$45{\cdot}6 \times 10^3$	10	23×10^4	$15{\cdot}9 \times 10^3$

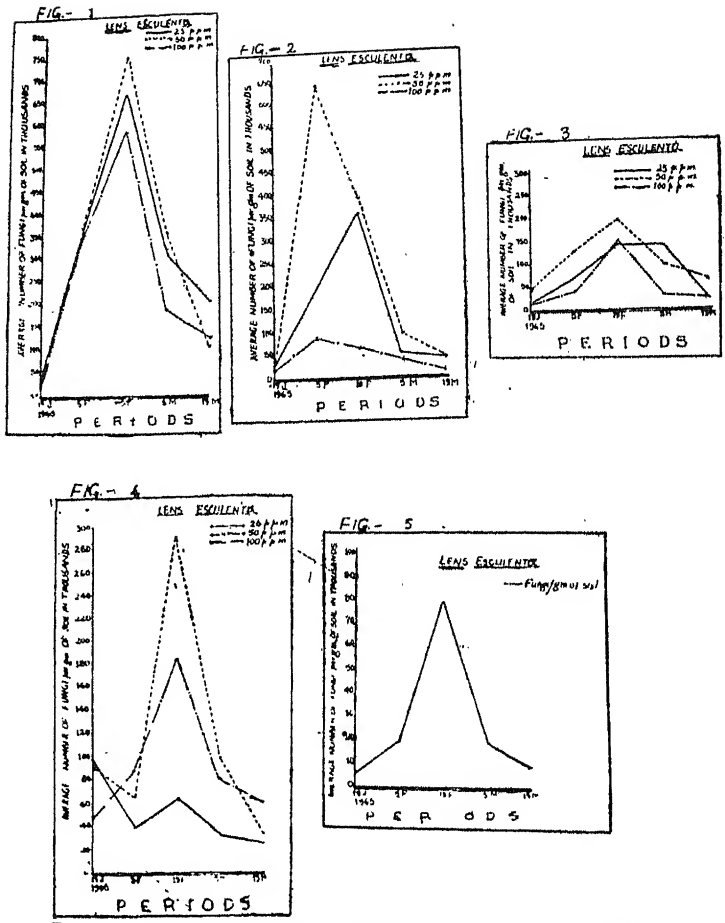

PLATE I. Effect of hormones on the rhizosphere fungal population of *Lens esculenta* (seed treatment method).

Fig. 1. Effect of three different concentrations of indole acetic acid.

Fig. 2. Effect of three different concentrations of indole 3-yl propionic acid.

Fig. 3. Effect of three different concentrations of 1–naphtha acetic acid.

Fig. 4. Effect of three different concentrations of 2-naphtha acetic acid.

Fig. 5. Control.

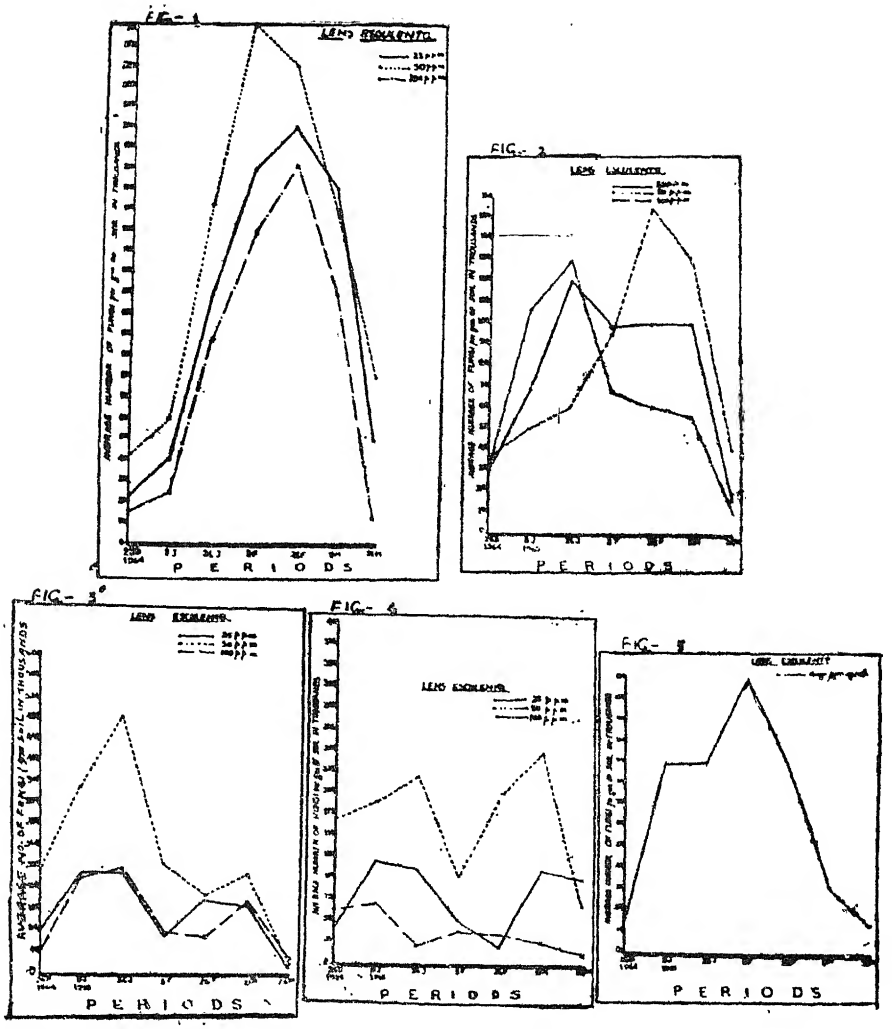

PLATE II. Effect of hormones on the rhizosphere fungal population of *Lens esculenta* (Foliar-spray method)

Fig. 1. Effect of three different concentrations of indole acetic acid.

Fig. 2. Effect of three different concentrations of 3-yl propionic acid.

Fig. 3. Effect of three different concentrations of 1-naphtha acetic acid.

Fig. 4. Effect of three different concentrations of 2-naphtha acetic acid.

Fig. 5. Control.

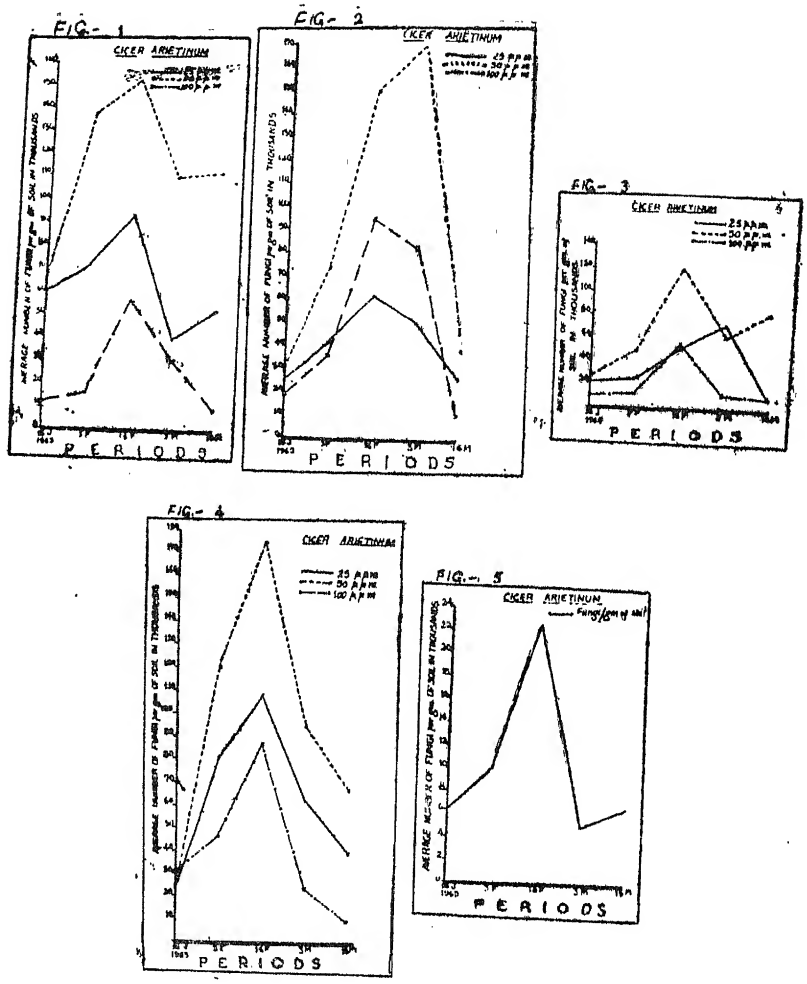

PLATE III. Effect of hormones on the rhizosphere fungal population of *Cicer aristinum* (Seed treatment method)

Fig. 1. Effect of three different concentrations of indole acetic acid.

Fig. 2. Effect of three different concentrations of 3-yl propionic acid.

Fig. 3. Effect of three different concentrations of 1-naphtha acetic acid.

Fig. 4. Effect of three different concentrations of 2-naphtha acetic acid.

Fig. 5. Control.

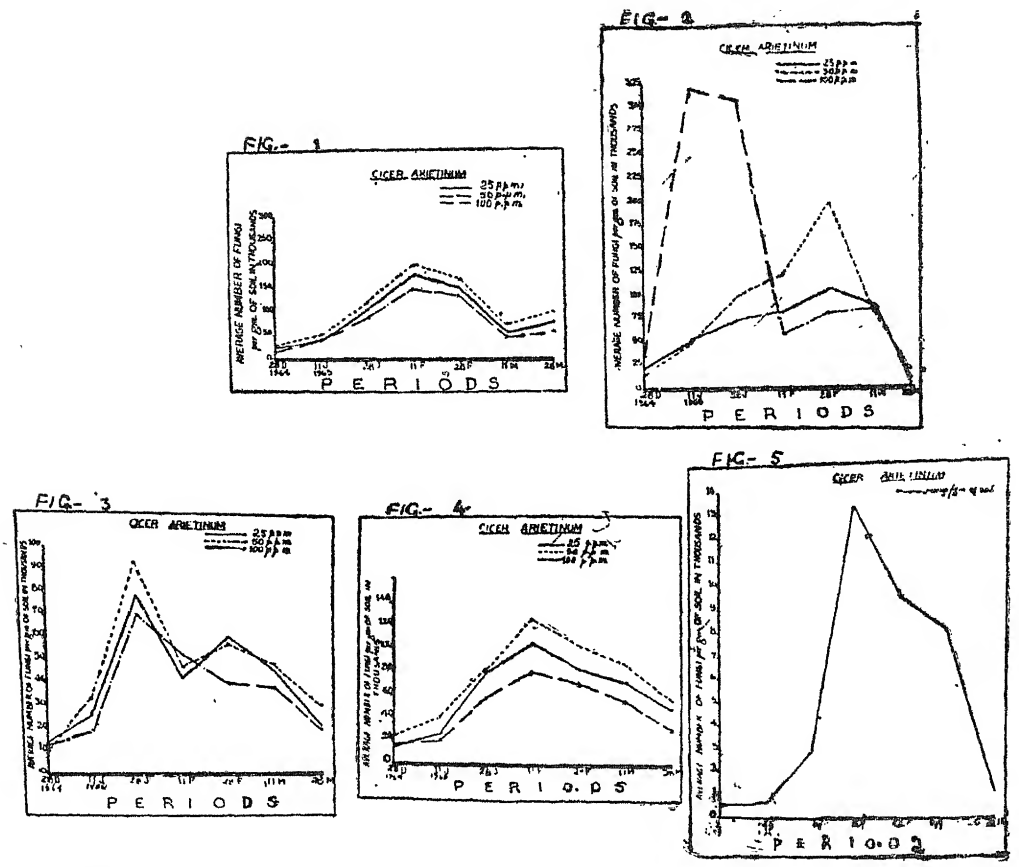

PLATE IV. Effect of hormones on the rhizosphere fungal population of *Cicer arietinum* (Foliar-spray method)

Fig. 1. Effect of three different concentrations of indole acetic acid.
Fig. 2. Effect of three different concentrations of indole 3-yl acetic acid.
Fig. 3. Effect of three dieffrent concentrations of 1-naphtha acetic acid.
Fig. 4. Effect of three different concentrations of 2-naphtha acetic acid.
Fig. 5. Control.

The following media were used ;

For the isolation of fungi :

Dextrose, 10 g. ; peptone, 5 g. ; KH_2PO_4, 1 g.; $MgSO_4$, 7–H_2O, 0·5 g. ; agar, 20 g. ; distilled water, 1 litre ; Rose bengal, 1 : 15,000.

For the isolation of bacteria :

Meat-extract, 3 g. ; peptone, 10 g. ; sodium chloride, 5 g. ; agar, 20 g. ; distilled water, 1 litre.

pH was adjusted to 7·6–7·8 by adding normal NaOH. The media were autoclaved at 15 pound pressure for 20 minutes.

Plates were incubated for 5 to 6 days in the case of fungi and for 2 to 3 days in the case of bacteria. Thereafter, the fungal and bacterial colonies were counted in each plate. The soil solution left after the inoculation was dried on a water-bath and finally in an oven at 105°C. for 24 hours and then weighed. From the

final weight of the soil, the soil present in one cc. of the solution was calculated. The number of fungi and bacteria per gram of dry soil was then calculated.

The experimental findings are summarized in the Tables I–IV plates I–IV.

Discussion

The experimental findings set out in the above tables reveal that the higher micro-population obtained was from the rhizosphere of *Lens esculenta*. The micro-organisms were generally low in number in the early stage of the plant growth and increased with the age of the plant, becoming the maximum when the plants attained maturity (Plates I–IV and Tables III and IV). Later on, the microbial population decreased.

In the case of all the four hormones in the present study, the 50 ppm. had positive effect and mostly the micro-population was the highest. In the rhizosphere of the same plants, the lowest population was recorded from 100 ppm. concentration, whereas the 25 ppm. concentration failed to induce appreciable stimulation. The variation in the micro-population isolated from the rhizospheres of the two plants treated with different concentrations of the four hormones is significant. It was interesting to find that the micro-population was always higher in the rhizosphere of the plants treated with hormones than in that of the control (Plates I–IV and Tables III–IV). However, most of the fungal species isolated were common in both the treatments and no fungi specific to different hormones were isolated (Tables I and II). The reason for the higher number of micro-organisms in the hormone-treated plants has not yet been determined, but it seems that the micro-organisms increased due to the increased growth of the roots of the plants.

Summary

The effect of four hormones on the fungal flora of the rhizosphere of *Lens esculenta* and *Cicer arietinum* was studied. The 25–, 50– and 100–ppm. concentrations of the hormones were applied by foliar spray and seed treatment methods. The 50–ppm. concentration stimulated the fungal flora and favoured the maximum rhizosphere fungi in the case of all the four hormones. The 25– and 100–ppm. concentrations were either less or more effective for the good growth of the rhizosphere micro-fungal flora.

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Fungal population in relation to temperature and moisture

By

R. R. MISHRA*

Department of Botany, Gorakhpur University, Gorakhpur (India)

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Introduction

The study of causes underlying the variation in number of micro-organisms has engaged the attention of numerous workers but opinions have been by no means unanimous regarding any positive effects of moisture content and temperature. Jensen (1931, *a*) concluded that a positive correlation exists between moisture and number of bacteria and a similar though less pronounced correlation exists between moisture content and number of fungi, whereas the number of actinomycetes do not seem to be influenced by changes in the moisture content. He further observed that none of these groups of organism showed any actual correlation with the temperature or any definite seasonal changes excepting those resulting from changes in moisture. Eggleton (1938) suggested a weekly variation in number of bacteria, actinomyces and fungi occurring in grassland soil. Statistical analysis has indicated a strong positive association between number of bacteria and the moisture status of the soil. According to him (Eggleton, 1938) somewhat similar though less established relationship appear to exist between the soil moisture content and number of actinomycetes and fungi, while soil temperature and soil reaction appear to exert no measurable influence on number of organisms.

However, no attempt has been made earlier in our country to investigate the influence of temperature and moisture content on the soil fungal population in three different seasons of the year, *viz.*, rainy, winter and summer.

July to October is rainy season, though sometimes the rain starts in the latter part of June and continues only upto middle of October. The maximum rainfall is always expected in the months of July, August and September. The rainy season is followed by winter which lasts from November to end of February. The coldest months of the season are December and January when the temperature is very low. These months are usually dry except for some occasional winter showers. The summer season starts from March and lasts till June. The temperature during this season is very high and hot wind "loo" is very common in these months. The hottest months are April and May. Sometimes in June the monsoon starts and there is a slight fall in temperature (Table VII).

Materials and methods

The two grassplots dominated by *Desmostachya bipinnata* Stapf (Plot I) and *Dichanthium annulatum* Stapf (Plot II) situated in the Banaras Hindu University campus were selected for the present investigation. The soil samples for fungal isolation were collected in every month. Methods for the collection of soil

*Formerly at Department of Botany, Banaras Hindu University, Varanasi.

samples, inoculation, isolation and purification of fungal species were adopted as described by the author (1965). The soil samples were collected from three different depths, *viz.*, 0–6″ (S_1), 6–12″ (S_2) and 12–18″ (S_3). Frequency of fungal species was recorded as suggested by Saksena (1955). The seasonal data was obtained by averaging the monthly ones.

The experimental findings are summarised in the tables I–VII.

TABLE 1

Average frequency of fungal species in different seasons in Plot 1

Fungal Species	Winter Season			Summer Season			Rainy Season		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Mucor luteus Linn.	1	1	1	1	1	2	2	1	1
Rhizopus nigricans Ehrenberg	2	1	1	–	–	–	1	1	1
Gongronella butleri (Lendn.) Peyronel and Dal vesco	2	1	1	–	–	–	–	–	–
Gongronella butleri var. *proliferans* Dwivedi	1	1	–	1	–	–	–	1	1
Choanephora cucurbitarum (Barkley and Ravenel) Thaxter	–	–	–	–	–	–	1	–	–
Cunninghamella blakesleeana Lendner	2	1	1	1	1	1	1	1	–
Syncephalastrum racemosum (Cohn) Schroeter	1	1	–	–	–	–	1	1	1
Saksenaea vasinformis Saks.	–	1	1	–	–	–	–	–	–
Chaetomium sp.	1	1	–	2	1	–	2	1	1
Neocosmospora vasinfecta E. F. Smith	1	1	1	1	1	1	1	1	1
Phoma hibernica Gremes, O'connor and cummins	1	–	–	1	–	–	1	1	–
Colletotrichum falcatum Went	1	–	–	–	–	–	–	–	–
Trichoderma viride Corda	1	1	1	1	1	1	1	1	1
Aspergillus niger Van Tiegham	3	3	2	5	4	4	5	4	4
A. fumigatus Fres.	3	1	–	5	2	1	4	2	1
A. awamori Nakazawa	3	2	2	2	1	–	2	2	–
A. terreus Thom	1	–	–	2	1	1	2	1	2
A. montevidensis Talice and Mackinnon	–	1	1	–	–	–	–	–	–
A. nidulans (Eidam) Winter	1	1	1	2	1	–	1	1	1
A. flavus Link	2	2	2	1	2	2	2	2	1
A. candidus Link	1	1	–	1	1	–	1	1	1
A. japonicus Saito	1	1	–	1	1	–	1	–	–

Fungal Species	Winter Season			Summer Season			Rainy Season		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
A. sulphureus (Fres.) Thom and Church	1	–	–	–	–	–	–	–	–
Penicillium humicola Oud.	5	3	3	1	2	2	3	3	3
P. spiculisporium Lehman	2	1	1	–	–	–	1	1	1
Paecilomyces fusisporus Saks.	1	1	1	2	1	–	1	1	1
P. varioti Bainier	1	1	–	1	–	–	1	1	1
Cephalosporium coremioides Raillo	1	1	1	–	–	–	–	–	–
Gliocladium fimbriatum Gilman and Abbott	1	1	–	1	–	–	–	–	–
Acrostalagmus cinnabarinus Corda	1	–	–	–	–	–	–	–	–
Verticillium terrestre (Link) Lindau	1	–	–	–	–	–	–	–	–
Curvularia lunata (Walker) Boedijn	1	1	1	1	1	1	1	1	–
Humicola fusco-atra Traaen	1	1	1	–	1	–	1	1	–
Cladosporium herbarum (Pers.) Link	4	2	1	–	–	–	–	–	–
Papulospora sp.	1	–	–	–	–	–	–	–	–
Alternaria humicola Oud.	1	1	–	1	1	–	1	–	–
Nigrospora sphaerica (Sacc.) Manson	–	–	–	–	–	–	–	–	–
Helminthosporium anomalum Gilman and Abbott	1	–	–	1	–	–	1	–	–
Scolecobasidium constrictum Abbott	–	1	–	1	1	–	1	1	–
S. terreum Abbott	–	–	–	1	–	–	2	1	–
S. verruculosum Roy, Dwivedi and Mishra	1	–	–	1	–	–	–	–	–
S. macrosporum Roy, Dwivedi and Mishra	1	1	–	–	–	–	–	–	–
Fumago sp.	–	–	–	1	–	–	1	1	–
Memnoniella echinata (Rivolta) Galloway	–	–	–	–	–	–	1	–	–
Stachybotrys aurantia Baron	1	–	–	–	–	–	–	–	
Fusarium nivale (Fries) cesati	2	2	–	1	1	–	2	3	–
F. chlamydosporum Wollenweber and Reinking	1	–	–	–	–	–	1	1	–
Myrothecium verrucaria (Albertini and Schweinitz) Ditmar	1	–	–	–	–	–	–	–	

TABLE II

Number of fungal species isolated from Plot I

Months	SOIL DEPTHS S_1	S_2	S_3	Months	SOIL DEPTHS S_1	S_2	S_3
November 1961	20	17	7	November 1962	14	11	8
December 1961	15	10	13	December 1962	18	15	9
January 1962	15	11	7	January 1963	18	9	7
February 1962	11	10	9	February 1963	10	7	5
March 1962	13	7	6	March 1963	12	5	3
April 1962	14	9	8	April 1963	9	9	3
May 1962	8	7	4	May 1963	7	7	3
June 1962	7	5	3	June 1963	9	6	5
July 1962	9	8	6	July 1963	9	14	7
August 1962	10	9	11	August 1963	18	10	9
September 1962	13	8	7	September 1963	17	16	12
October 1962	18	11	7	October 1963	15	18	7

TABLE III

Average number of fungi/gm. dry soil in Plot I

Months	SOIL DEPTHS S_1	S_2	S_3	Months	SOIL DEPTHS S_1	S_2	S_3
Nov. 1961	43409	54311	21995	Nov. 1962	68540	26105	15676
Dec. 1961	39181	36432	31428	Dec. 1962	23493	12939	10971
Jan. 1962	49889	18771	20318	Jan. 1963	18958	7665	14867
Feb. 1962	29835	11225	9078	Feb. 1963	15475	4546	3091
March 1962	24693	9655	8809	March 1963	12415	3774	2449
April 1962	17830	7810	6605	April 1963	13744	2281	3225
May 1962	13726	6634	3907	May 1963	12593	2862	2646
June 1962	10559	3486	3114	June 1963	16685	3731	2721
July 1962	41390	5694	4795	July 1963	29330	13229	11418
August 1962	32888	11265	9689	August 1963	35246	13842	9977
Sept. 1962	59954	15223	14219	Sept. 1963	51306	17986	7918
Oct. 1962	89085	35869	20120	Oct. 1963	59352	21678	16755

TABLE IV

Average frequency of fungal species in different seasons in Plot II

Fungal species	Winter Season			Summer Season			Rainy Season		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Mucor luteus	1	3	1	1	1	1	1	1	1
Rhizopus nigricans	–	1	–	1	–	–	–	1	1
Chunninghamella blakesleeana	1	1	–	1	1	1	1	–	–
Syncephalastrum racemosum	1	1	1	–	–	–	–	1	1
Thielavia terricola (Gilman and Abbott) Emmons	2	1	–	4	1	–	2	1	–
Chaetomium globosum Kunze	2	1	–	2	1	–	–	–	–
C. funicola Cooke	–	–	–	–	–	–	1	1	–
Chaetoceratostoma longirostre Farrow	–	–	–	1	1	2	–	–	–
Neocosmospora vasinfecta	1	1	2	–	–	–	1	2	1
Trichoderma viride	1	1	1	–	–	1	1	2	2
Aspergillus niger	3	4	4	4	4	5	5	4	4
A. fumigatus	3	1	–	5	1	1	4	2	1
A. terreus	1	1	1	5	3	3	1	1	–
A. awamori	–	–	–	1	–	–	1	1	–
A. nidulans	1	1	1	1	1	1	1	1	1
A. flavus	1	1	1	–	–	–	2	1	1
A. sulphureus	1	–	1	–	–	–	–	–	–
A. japonicus	–	–	–	1	1	1	1	1	1
A. candidus Link	–	–	–	–	–	–	1	1	–
Penicillium humicola	1	1	1	1	2	3	2	2	3
P. spiculisporium	1	1	–	–	–	–	–	–	–
Paecilomyces fusisporus	3	3	1	5	3	2	5	2	–
P. varioti	1	1	1	–	1	1	–	1	1
Gliocladium roseum (Link) Thom	1	–	–	–	–	–	–	–	–
Curvularia lunata	1	1	1	2	1	1	1	1	1
Humicola fusco-atra	2	1	–	–	–	–	1	1	–
Alternaria humicola	–	–	–	–	1	1	–	–	–
A. tenuis Nees	–	–	–	–	–	–	1	–	–
Nigrospora sphaerica	–	–	–	1	–	–	–	1	1
Fumago sp.	1	1	–	–	–	–	1	2	–
Scolecobasidium terreum	–	–	–	–	1	1	–	1	1
S. macrosporum	–	–	1	–	–	–	–	–	–
Spegazzinia sp.	–	–	–	–	–	–	1	–	–
Fusarium nivale	1	1	1	–	2	2	3	3	4
F. chlamydosporum	–	1	1	–	–	–	1	1	–
Myrothecium roridum Tode	1	1	–	–	–	–	1	1	–

TABLE V

Number of fungal species isolated from Plot II

Months		SOIL DEPTHS S_1	S_2	S_3	Months		SOIL DEPTHS S_1	S_2	S_3
November	1962	12	8	6	May	1963	7	9	8
December	1962	14	12	12	June	1963	10	10	8
January	1963	14	7	5	July	1963	12	11	8
February	1963	11	10	6	August	1963	17	12	8
March	1963	12	8	7	September	1963	21	16	9
April	1963	10	10	8	October	1963	15	16	10

TABLE VI

Average number of fungi/gm. dry soil in Plot II

Months		SOIL DEPTHS S_1	S_2	S_3	Months		SOIL DEPTHS S_1	S_2	S_3
Nov.	1962	61858	38037	24810	May	1963	11210	3016	3084
Dec.	1962	19256	14473	12145	June	1963	20755	9627	2535
Jan.	1963	18667	6469	2702	July	1963	30636	13140	8957
Feb.	1963	10761	3290	2328	August	1963	42335	15707	11903
March	1963	13019	2783	2168	Sept.	1963	51060	15605	12770
April	1963	13021	2114	2123	Oct.	1963	63359	22941	13764

TABLE VII

Climatalogical data

Months		Av. Max. temp. °C	Av. Min. temp. °C	Rainfall in inches	Months		Av. Max. temp. °C	Av. Min. temp. °C	Rainfall in inches
Nov.	1961	27·9	13	–	Nov.	1962	29·6	13·1	–
Dec.	1961	20·0	5·1	0·55	Dec.	1962	24·4	11·0	0·68
Jan.	1962	22·5	7·85	0·73	Jan.	1963	22·3	7·1	0·85
Feb.	1962	27·0	12·8	0·6	Feb.	1963	26·8	11·8	0·39
March	1962	33·5	17·5	0·66	March	1963	34·1	15·4	0·78
April	1962	39·2	22·0	–	April	1963	40·18	21·4	0·05
May	1962	42·5	26·3	0·56	May	1963	40·8	24·3	0·58
June	1962	40·2	26·8	1·14	June	1963	38·4	26·6	3·65
July	1962	36·5	27·5	11·82	July	1963	31·9	26·5	13·57
August	1962	32·5	26·0	16·54	August	1963	33·18	23·4	9·6
Sept.	1962	32·3	25·0	10·49	Sept.	1963	32·9	26·6	8·59
Oct.	1962	32·6	19·0	0·91	Oct.	1963	32·0	19·9	0·99

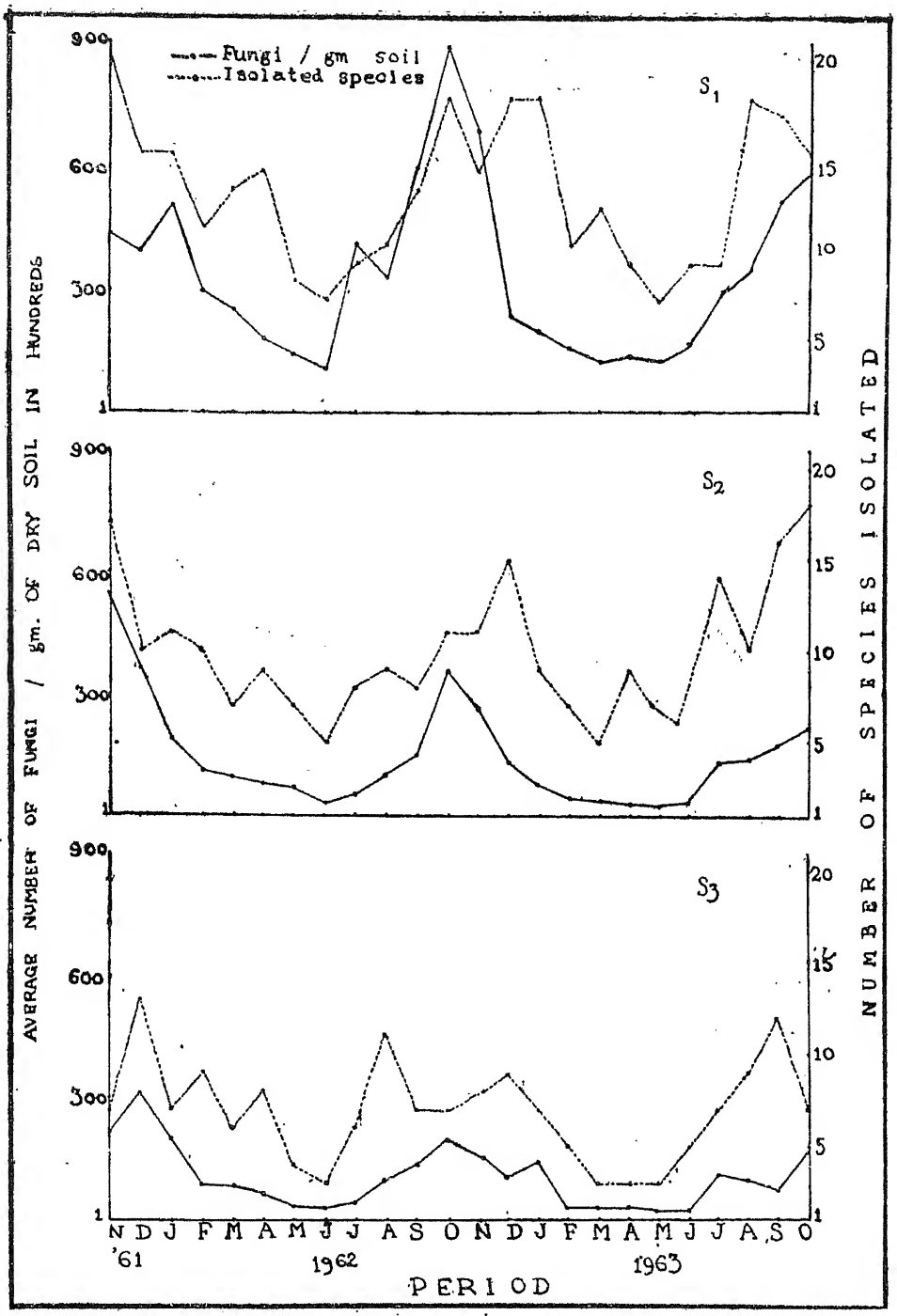

PLATE I. Distribution of fungal population in three soil depths of plot I.

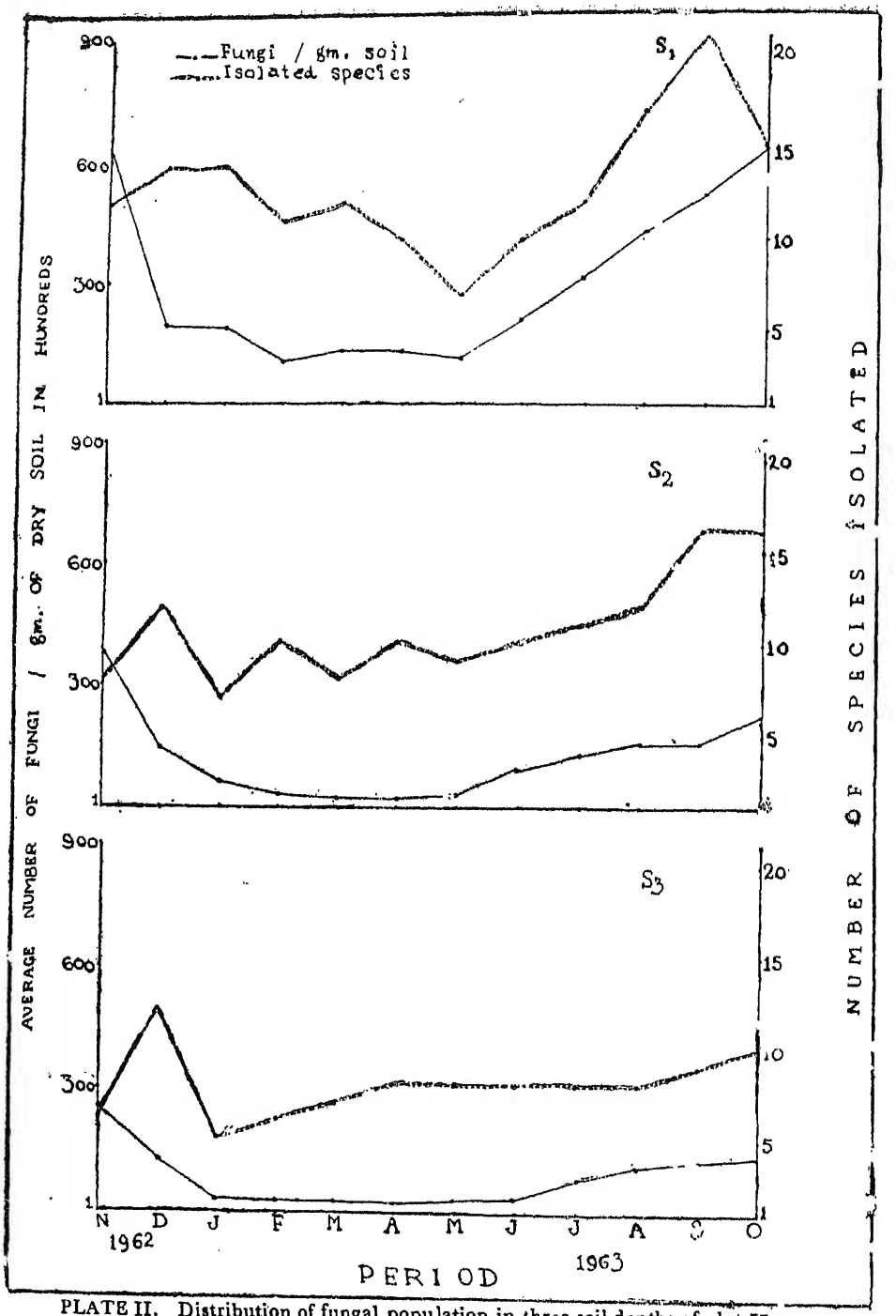

PLATE II. Distribution of fungal population in three soil depths of plot II.

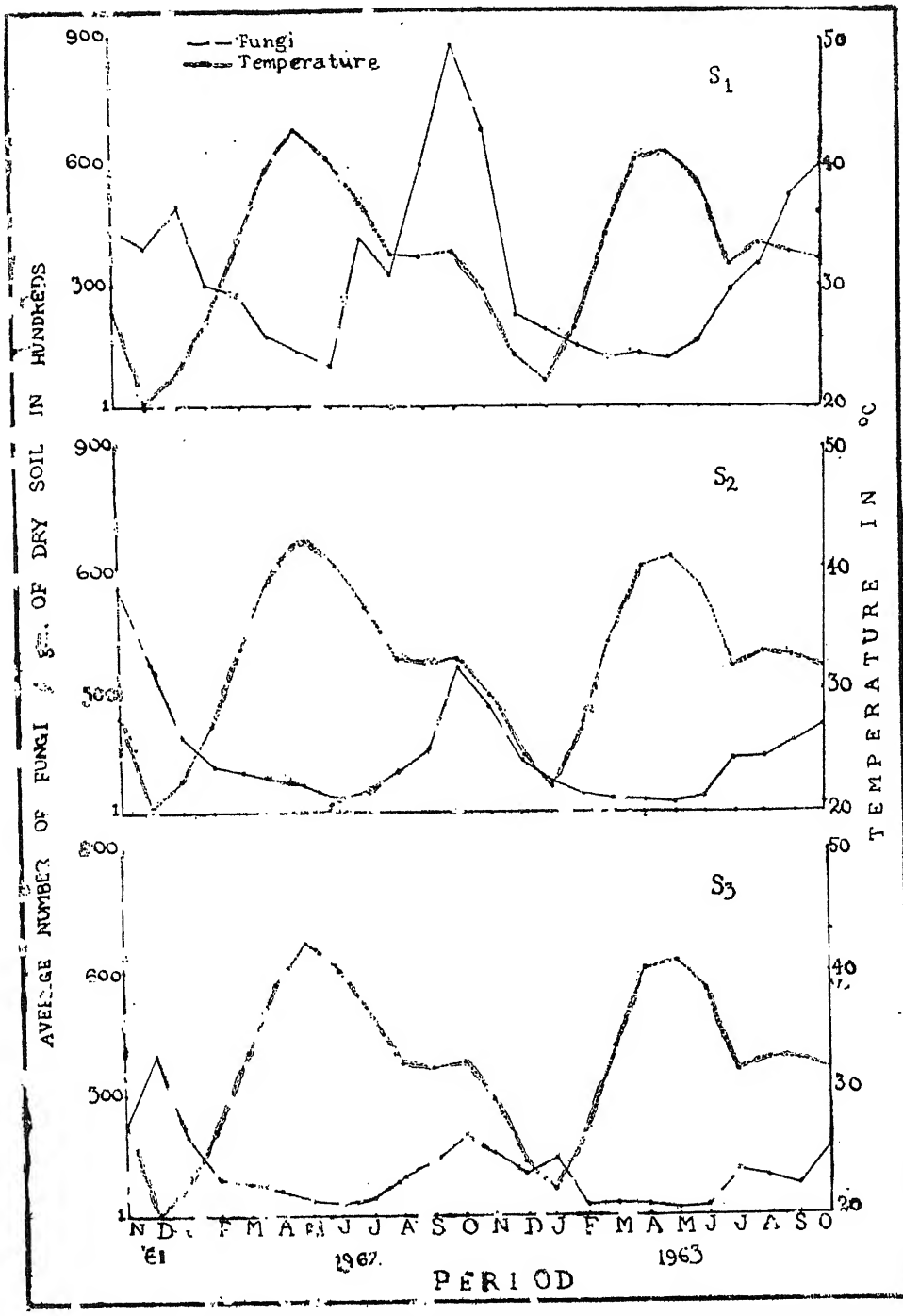

PLATE III. Effect of temperature on fungal population in three soil depths of plot I.

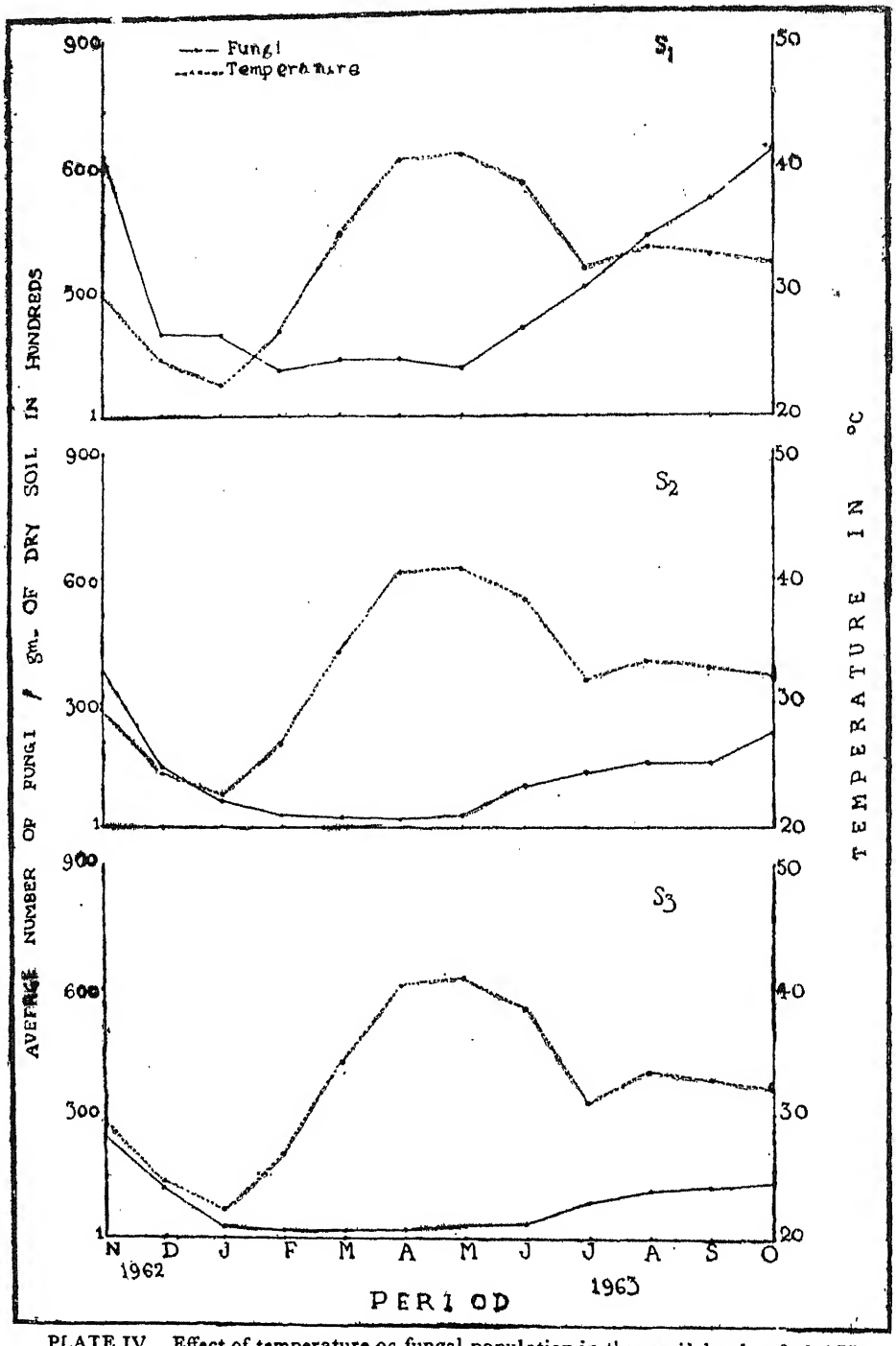

PLATE IV. Effect of temperature on fungal population in three soil depths of plot II.

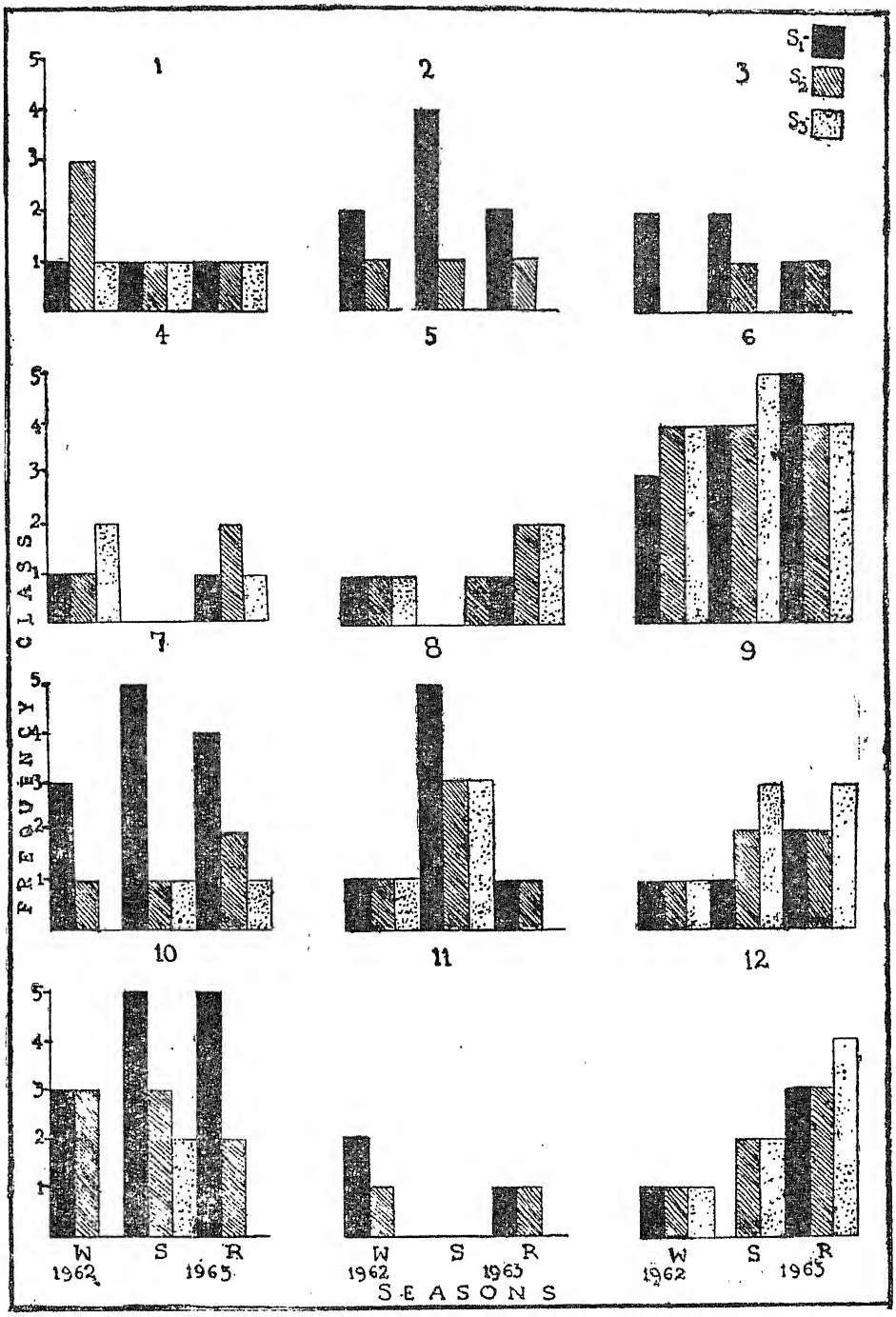

PLATE V. Histograms showing frequency class of some common species isolated from plot I

1. *Mucor luteus.*
2. *Cunninghamella verticillata.*
3. *Fusarium nivale.*
4. *Humicola fusco-atra.*
5. *Penicillium humicola.*
6. *Paecilomyces fusisporus.*
7. *Aspergillus awamori.*
8. *A. flavus.*
9. *A. niger.*
10. *A. fumigatus.*

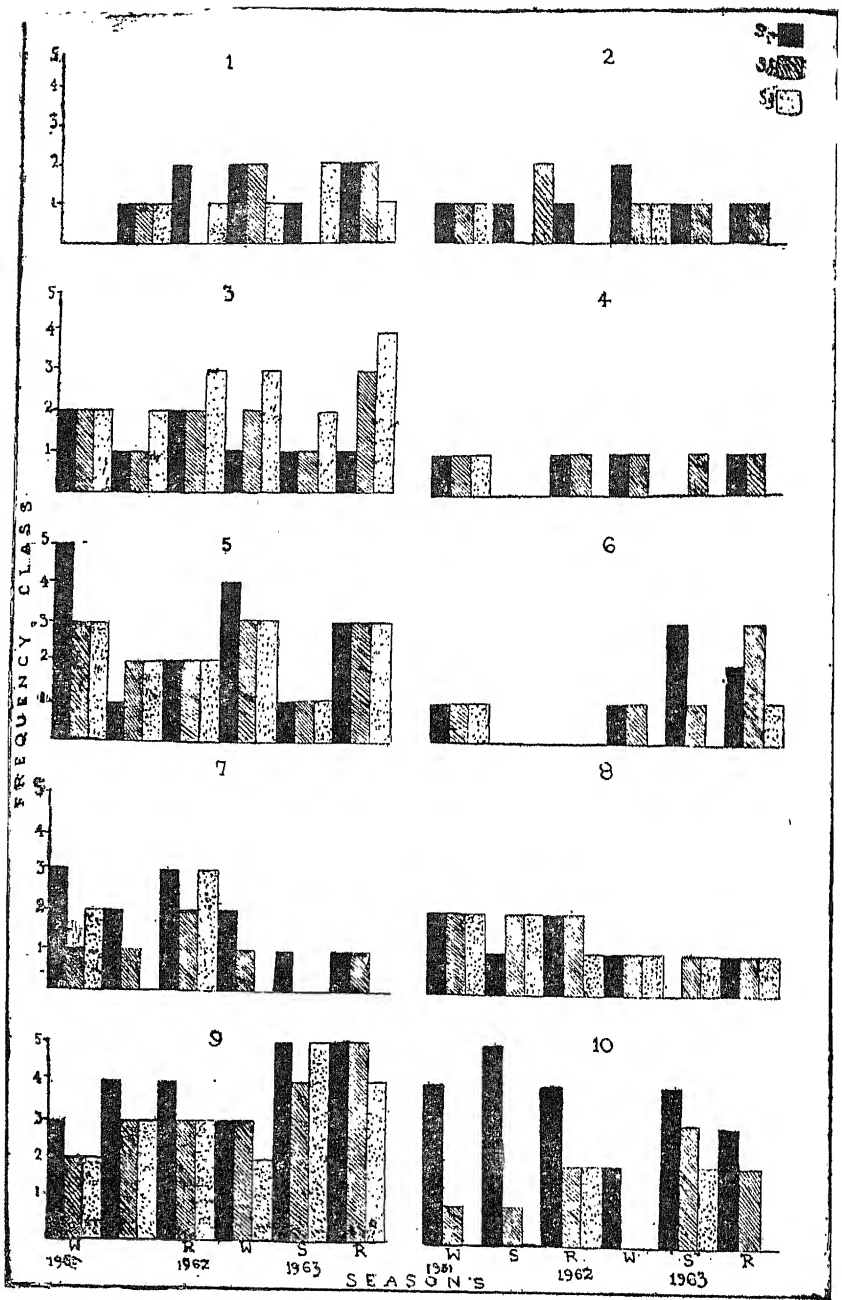

PLATE VI. Histogram showing frequency class of some cammon species isolated from plot II.

1. *Mucor luteus.*
2. *Thielavia terricola.*
3. *Chaetomium globosum.*
4. *Neocosmospora vasinfecta.*
5. *Trichoderma viride.*
6. *Aspergillus niger.*
7. *A. fumigatus.*
8. *A. terreus.*
9. *Penicillium humicola.*
10. *Paecilomyces fusisporus.*
11. *Humicola fusco-atra.*
12. *Fusarium nivale.*

Result and discussion of data

The soil fungal population which touched the lowest peak in the hot summer months of April and May (Tables II, III, V, VI ; plates I, II) when the temperature was considerably high (Table VII) exhibited a sudden increase in the month of June. In later part of June, in general, an increase in fungal population was observed which appers to be due to increased moisture status of the soil on account of rainfall during this period. In June also the temperature approximates to that of previous months temperature (Table VII). Thus it appears, the high temperature in the summer is not directly much responsible for reduction in fungal counts but rather it acted indirectly by influencing the moisture regime of the soil.

In the month of July when sufficient precipitation is obtained, not withstanding the high temperature, the fungal population showed a continuous increase (Tables II, III, V, VI ; plates I–IV). The increasing tendency continued and reached the maximum in the month of October (plates I–II). The maximum rainfall in the month of August and September (Table VII) resulted in the highest moisture level of the soil but the highest peak of the fungal population did not coincide exactly with the moisture status of the soil. The month of October was most favourable for the growth and sporulation of fungi in soil because the maximum organic matter (Mishra, 1966 *a*, *b*), suitable temperature and sufficient moisture content, the three dominant governing factors of soil fungal population are adequately available at that time. The grasses generally start drying up at the end of rainy season and subsequently are decomposed in presence of sufficient moisture and favourable temperature adding appreciable organic matter content in the soil.

From November onwards the fungal population decreased continuously and reached its lowest peak in the month of May. During winter season the moisture and organic matter content of the soil were not appreciably reduced (Mishra, 1966, *b*). The low temperature prevailing in the season, therefore, appears to be responsible for decrease in fungal population (Tables II, III, V, VI ; plates III–IV).

Peculiarly enough the fungal population did not show any increase in the month of February and March though the temperature during these months happen to be favourable (Table VII). The decrease in fungal population observed during these two months is probably due to reduction in moisture and organic matter content of the soil. The population was further decreased and reached the lowest during April and May. Besides, low moisture and reduced organic matter of the soil, high temperature also prevails in this period (Table VII). All the above three factors adversely affect the fungal growth and consequently the lowest fungal population is recorded during this period of the year.

Seasonal Variation in fungal population

Though the maximum fungal population was recorded from both the plots in the beginning of the winter season and the lowest in summer months both in quality and quantity there does not seem to be any definite pattern of distribution of the fungal species in different seasons (Tables I, IV). There are no forms specific to rainy, winter or summer seasons. Whereas a few forms, *viz.*, *Aspergillus niger*, *A. fumigatus*, *A. aureamori* and *Penicillium humicola* in plot I ; and *A. niger*, *A. fumigatus* and *Paecilomyces fusisporus* in plot II were dominant throughout the year (Tables I, IV and plates V–VI) other isolates were cultured with low frequency (Tables I, IV). Similar observations were made by the author (1965, 1966 *a*) while investigating the fungal flora of grasslands of *Saccharum spontaneum* Linn. and *Vetiveria zizanioides* Nash. Similar views were also expressed by workers like Snow

(1935), Cobb (1932), Fehr (1929), Vandecaveye and Katznelson (1938), Warcup (1951) and England and Rice (1957).

Summary

An investigation into the soil fungal population of two grasslands dominated by *Desmostachya bipinnata* Stapf and *Dichanthium annulatum* Stapf in relation to temperature and moisture was undertaken. It is observed that the maximum fungal population was recorded in the month of October when the suitable temperature, sufficient moisture and organic matter was available in the soil. Later on the population decreased continuously attaining the lowest peak in the month of May. In winter months the low fungal count was probably due to low temperature and in summer season, the high temperature, low moisture content and reduced organic matter, all combined together were responsible for decrease in fungal population. With the onset of monsoon generally in the month of June, the moisture status of the soil is raised and consequently a gradual increase in fungal flora was recorded. which attained the highest peak in the month of October. However, there is no definite pattern of distribution of fungal species in three different seasons, viz., rainy, winter and summer of the year and no forms specific to any particular season were cultured. *A. awamori*, *Penicillium humicola* and *Paecilomyces fusisporus* were dominant throughout the year and a number of others were isolated with low frequency.

Acknowledgements

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Variations in fifteen different isolates of *Pestalotiopsis versicolor* (Speg.) Stey.

By

D. K. PUROHIT & K. S. BILGRAMI

Department of Botany, Jodhpur University

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The taxonomy of the genus *Pestalotiopsis* has been a subject of sufficient controversy and discussion during the recent years. The conidial morphology, its dimensions, colour, mode of septation as well as the number of setulae borne over the superior hyaline cell of the conidium are some of the criteria which have been used for proper systematization of species in this genus. Steyaert (1949) accommodated the versicolorous forms in section trisetulatae. Guba (1961) described about 98 such species under two groups (Versicolorae, Umberae-Olivae and Versicolorae, Fuliginae-Olivae). Preliminary investigations by the authors revealed that the versicolorous nature of some of the isolates varied under cultural conditions. The perspective of the present paper was to undertake comparative studies of fifteen different isolates of *Pestalotiopsis versicolor*. The isolates (11, 18, 20, 25, 31, 32, 34, 43, and 48) have been recovered from new hosts. The colour, size as well as the percentage of the setulae in four successive generations have been studied.

The main aim of the present investigation was to record the changes in the conidial colour of *Pestalotiopsis versicolor* during different generation as in the past the versicolourous forms have often been described as concolorous and *vice-versa*.

Materials and Methods

Pestalotiopsis versicolor was recovered from the diseased leaves of *Buxus sempervirens* Thunb. (Isolate No. 11). *Celtis cinnamonea* Lindl. (Isolate No. 16), *Cinnamomum obtusifolium* Nees. (Isolate No. 18), *Cornus amomum* Mill. (Isotate No. 20), *Cymbidium pendulum* Sw. (Isolate No. 22), *Deutzia corymbosa* R.Br. (Isolate No. 25), *Glochidion accuminatum* Muell. (Isolate No. 31), *Helicia erractica* Hook. (Isolate No. 32), *Ilex aquifolium* Linn. (Isolate No. 34), *Metasequoia glyptostroboides* Hu & Cheng. (Isolate No. 43), *Phoenix rupicola* T. Anders. (Isolate No. 48), *Pyrus sikkimensis* Hook (Isolate No. 55), *Royena lucida* Linn. (Isolate No. 60), *Rubus ellipticus* R. Br. (Isolate No. 59), and *Viburnum colebrookeanum* Wall. (Isolate No. 67). Asthana and Hawker's medium A was used as the basal medium. The methods for purification and subculturing were the similar to those used by Bilgrami (1963). First four conidial generations were used for comparative morphological studies. Monosporic cultures were raised in each case.

Observations

The variation in the colour of the three intermediate cells of conidia of 15 different isolates of *P. versicolor* during four successive generations are presented in Table 1.

A study of Table 1 shows that the versicolorous nature of the conidia was not a consistent character in most of the isolates. In isolates (18, 20, 25, 31, 32,

34, 48 and 60) both versicolorous and concolorous types of conidia were obtained in cultures. In some of the cases, for example, in isolate number 34, the conidia of the two types were present in all the generations while in other cases either both the types of conidia were present or the colour changes were recorded in different generations. In certain other isolates (11, 22, 31 and 32) the versicolorous character was lost during the 3rd generation and again acquired in the 4th generation. In isolates (16, 48, 60 and 67) the versicolorous nature was retained till the 3rd generation but it was lost in the 4th one. In isolates (43 and 55) the concolorous conidia were present in both 3rd and 4th generations.

TABLE 1

Showing the variation in conidial col ur of 15 isola es of P. versicolor

Isolate number	1st conidial generation	2nd conidial generation	3rd conidial generation	4th condial generation
11	Versicolorous	Versicolorous & Concolorous	Concolorous	Versicolorous
16	Versicolorous	Versicolorous	Versicolorous	Concolorous
18	Veriscolorous	Versicolorous	Versicolorous	Veriscolorous & Concolorous
20	Versicolorous & Concolorous	Versicolorous	Versicolorous	Versicolorous & Concolorous
22	Versicolorous	Versicolorous	Concolorous	Versicolorous
25	Versicolorous & Concolorous	Versicolorous & Concolorous	Versicolorous	Versicolorous
31	Versicolorous & Concolorous	Versicolorous & Concolorous	Concolorous	Versicolorous
32	Versicolorous & Concolorous	Versicolorous	Concolorous	Versicolorous
34	Versicolorous & Concolorous	Versicolorous & Concolorous	Versicolorous & Concolorous	Versicolorous & Concolorous
43	Versicolorous	Versicolorous	Concolorous	Concolorous
48	Versicolorous	Versicolorous	Versicolorous & Concolorous	Concolorous
55	Versicolorous	Versicolorous	Concolorous	Concolorous
60	Versicolorous & Concolorous	Versicolorous & Concolorous	Versicolorous & Concolorous	Concolorous
59	Versicolorous	Versicolorous	Versicolorous	Versicolorous
67	Versicolorous	Versicolorous	Versicolorous	Concolorous

TABLE 2

Showing the variation in the number of setulae of conidia of 15 isolates of P. versicolor

Isolate	1st conidial generation				2nd conidial generation				3rd conidial generation				4th conidial generation			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
11		30%	70%			18%	82%		2%	28%	70%			22%	76%	2%
16		54%	46%		%	16%	82%			12%	84%	4%		50%	46%	4%
18		12%	88%			32%	68%			14%	86%			20%	80%	
20	4%	78%	18%			6%	88%	6%		24%	70%	6%		52%	38%	10%
22		18%	78%	4%		22%	76%	2%		65%	35%			22%	68%	10%
25		34%	66%		2%	28%	70%			28%	68%	4%		20%	74%	6%
31		26%	74%			14%	86%			16%	74%	10%		58%	40%	2%
32	2%	28%	70%			20%	80%			16%	82%	2%		4%	76%	20%
34		38%	54%	8%		32%	68%			8%	60%	32%		22%	68%	10%
43		24%	76%			26%	74%			30%	70%			70%	30%	
48		38%	57%	5%		30%	70%		3%	27%	66%	4%		62%	38%	
55		26%	70%	4%		30%	64%	6%	4%	38%	56%	2%		48%	44%	8%
60		28%	70%	2%		11%	86%	3%		12%	84%	4%		66%	32%	2%
59		15%	80%	5%		11%	85%	4%		12%	82%	6%		42%	54%	4%
67		38%	57%	5%		16%	84%			14%	84%	2%		48%	44%	8%

TABLE 3

Showing the variation in conidial size of 15 isolates of P. versicolor

Isolate number	1st conidial generation	2nd conidial generation	3rd conidial generation	4th conidial generation
11	18·9–27·0μ × 5·4–6·21μ	18·9–27·0μ × 4·86–6·21μ	18·9–29·7μ × 4·86–6·21μ	18·9–27·0μ × 5·4–7·29μ
16	18·9–35·1μ × 2·97–5·4μ	16·2–29·7μ × 3·24–5·4μ	17·55–27·0μ × 4·05–5·4μ	16·2–27·0μ × 2·97–5·4μ
18	18·9–27·0μ × 4·86–6·21μ	21·6–28·35μ × 4·86–5·94μ	20·25–28·35μ × 4·86–5·94μ	18·9–27·0μ × 5·4–6·21μ
20	18·9–27·0μ × 3·78–6·21μ	17·85–27·27μ × 4·86–7·29μ	18·9–27·0μ × 5·4–7·56μ	18·9–27·0μ × 5·13–6·75μ

Isolate number	1st conidial generation	2nd conidial generation	3rd conidial generation	4th conidial generation
22	18·9–29·7μ × 4·86–6·75μ	17·55–28·33μ × 5·4–6·21μ	16·2–27·0μ × 5·4–6·75μ	18·9–32·4μ × 5·67–7·29μ
25	17·85–31·86μ × 4·05–6·21μ	18·9–32·94μ × 3·78–7·29μ	18·9–31·05μ × 4·86–7·29μ	18·9–29·7μ × 5·4–7·56μ
31	18·9–27·0μ × 5·4–6·21μ	17·55–28·35μ × 5·4–7·56μ	18·9–29·7μ × 5·4–7·56μ	18·9–28·35μ × 5·13–6·21μ
32	18·9–32·4μ × 5·4–6·75μ	18·9–31·05μ × 5·4–6·21μ	18·9–31·05μ × 4·86–6·75μ	18·9–29·7μ × 5·4–8·1μ
34	18·9–27·0μ × 4·05–5·4μ	18·9–28·35μ × 4·86–6·48μ	18·9–29·7μ × 5·4–7·56μ	21·6–32·4μ × 5·13–6·75μ
43	18·9–29·7μ × 3·24–5·4μ	18·9–31·05μ × 4·86–5·94μ	18·9–32·4μ × 5·13–6·75μ	18·9–27·0μ × 4·05–5·4μ
48	18·9–31·05μ × 5·4–6·75μ	17·55–27·0μ × 5·4–7·56μ	18·9–29·4μ × 5·4–7·56μ	18·9–27·0μ × 5·4–6·21μ
55	18·9–27·0μ × 4·86–6·21μ	17·55–27·0μ × 5·4–6·75μ	16·2–27·0μ × 5·4–6·02μ	17·55–24·3μ × 4·86–5·67μ
60	18·9–27·0μ × 5·13–7·56μ	18·9–27·0μ × 5·4–6·75μ	17·85–27·0μ × 4·86–5·94μ	18·9–32·4μ × 5·4–7·26μ
59	18·9–28·35μ × 5·13–7·56μ	18·9–31·05μ × 5·4–8·1μ	17·55–31·05μ × 5·4–7·56μ	18·9–32·4μ × 5·4–7·29μ
67	18·9–32·4μ × 5·13–6·75μ	17·85–35·1μ × 4·86–7·29μ	18·9–32·4μ × 5·4–8·1μ	18·9–27·0μ × 4·86–5·4μ

The variation in the number of setulae of conidia of 15 different isolates of *P. versicolor* during four successive generations are presented in Table 2

Table 2 shows that in general the trisetulate conidia were predominant but in certain isolates like (31, 43, 48, 55, 60 and 67) the percentage of bisetulate conidia was higher than the trisetulate one in the 4th generation. In isolates 16 and 20 the bisetulate conidia were predominant in first and fourth generations.

The variation in the size of conidia of 15 different isolates of *P. versicolor* during four successive generations are presented in Table 3.

Table 3 obviously indicates that the conidial size of the isolates (11, 18, 20, 25, 31 and 55) showed slight variations. The length of the conidia of the

organisms (16 and 22) displayed great fluctuations. The isolates (32, 34, 43, 48, 59, 60 and 67) showed significant flexibility in their length as well as in width, in all the generations.

Discussion

The present investigations reveal that different isolates of *Pestalotiopsis versicolor* exhibited considerable variations in the conidial colour. In the past, all such isolates which possessed versicolorous conidia have generally been placed in this species. The authors also observed that in many cases the versicolorous nature was lost or altered when the organisms were brought in culture. By no means this character can be relied upon and used as basis for specific designation. The section trisetulatae proposed by Steyaert (1949) to accommodate the versicolourous forms seems to be quite appropriate as the percentage of trisetulate conidia were usually predominant. However, the behaviour of some isolates exhibited that even this character was considerably modified in the 4th generation. It may also be concluded that probably during continuous subsculturing the original characters were greatly modified. Therefore, it would be proper, if the morphology of this genus is studied under uniform conditions. In their recent paper Dube and Bilgrami (1966) reported that there was no consistency regarding the percentage of setulae in both the versicolorous and concolorous forms of *Pestalotiopsis*.

In genus *Pestalotiopsis* there has been considerable proliferation of the species on the basis of size and colour of the conidia as well as percentage and length of setulae. Besides, *P. versicolor* there are large number of other species which are characterized by the presence of versicolorous conidia. We are of the opinion that all such species of *Pestalotiopsis* which have been created only on the basis of conidial colour or the percentage of setulae should be thoroughly reexamined under uniform conditions.

Summary

Pestalotiopsis versicolor was recorded on eleven new hosts. Detailed investigations on fifteen different isolates were undertaken in four successive generations and it was observed that the colour, percentage of setulae as well as the dimensions of the conidia exhibited fluctuation in different generations.

Acknowledgement

The authors are thankful to the Head of Department for providing laboratory facilities.

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Studies on larval trematodes. I. On a new Echinostome cercaria, *Cercaria tetraglandulata* n.sp. from *Indoplanorbis exustus*

By

KM. SARLA SRIVASTAVA

Zoology Department, Lucknow University, Lucknow

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Introduction

About 609 snails, *Indoplanorbis exustus* were collected from the ponds, in and around Lucknow and examined for the larval trematodes. Of these out of about hundred specimens of the snail collected from the pond located in the village Gazipur, only one was found infected with this Echinostome cercaria.

Cercaria tetraglandulata n.sp.

Observations

The body (Fig. 1) of the cercaria is spinose, with narrow anterior and a broad round posterior end. It measures 0·375–0·420 mm. in length and 0·210–0·300 mm. in width in live specimens and 0·225–0·270 mm. in length and 0·075–0·105 mm. in width in fixed specimens. The spines of the body are arranged in transverse rows and present all over the body. The tail is spinose, longer than the body and measures 0·450–0·525 mm. in length and 0·060–0·075 mm. in width near the base of the body in live specimens and 0·300–0·376 mm. in length and 0·045 mm. in width in fixed specimen. The caudal fin (Fig. 1) is present in the form of two small membranes on the lateral margins of the tail, near the distal end of tail. A number of small rounded nuclei are seen embedded in the tail parenchyma and these are arranged in slightly irregular parallel rows. The tail, on contraction appears transversely striated throughout its whole length.

The oral sucker is terminal, spherical or subspherical, measuring 0·052–0·060 mm. in diameter in live specimens and 0·032–0·036 mm. in diameter in fixed specimens. The ventral sucker is slightly larger than the oral sucker, situated a little behind the equatorial line of the body, and measures 0·060– 0·072 mm. in diameter in live specimens while 0·040–0·044 mm. in diameter in fixed specimens. The cephalic collar is well developed, armed with 42 collar spines, which are arranged in single row. All the collar spines are roughly of equal size and measure 0·012 mm. in length. The end group spines are absent. A paired refractile dorsal body is present near the posterior margin of the oral sucker. A prepharynx is present, which is followed by a muscular pharynx, measuring 0·020–0·024 mm. in diameter in live specimens and 0·016–0·020 mm. in diameter in fixed specimens. The oesophagus measures 0·088–0·144 mm. in length. It bifurcates, at a short distance in front of the ventral sucker, into two intestinal caeca, which extend posteriorly almost upto the posterior end of the body. There are four pairs of penetration glands which are located one behind the other, on either side of the oesophagus. Each gland contains a nucleus and fine granules which take light

pink stain with neutral red. They open to the exterior by means of separate pores near the anterior end of the body, close to the mouth. The cystogenous gland cells are present all over the body. They are irregular in shape and contain small rod-like bodies which are arranged in parallel rows.

The genital rudiments (Fig. 1) are present just infront and behind the ventral sucker, in the form of spherical or subspherical masses of darkly staining cells. Further, they are joined together by a row of Cells. The genital pore is not yet developed.

The excretory bladder (Fig. 2) consist of two chambers a transversely oval posterior chamber and a small T-shaped anterior chamber. The two main collecting canals open, one on each side, on the antero-lateral side of the anterior chamber of the excretory bladder. The capillaries of two flame cells near the oral sucker, unite to form the anterior collecting canal, which runs posteriorly upto the region of the anterior border of the ventral sucker. The capillaries of two flame cells, at the level of oesophagus unite together and open into the anterior collecting canal. Similarly capillaries of two flame cells, near the posterior end of the body, unite to form the posterior collecting canal. Capillaries of a pair of flame cells open into the posterior collecting canal at the middle level of the ventral sucker. The posterior collecting canal, on each side, runs anteriorly upto the anterior border of ventral sucker, where it joins with the anterior collecting canal and forms the main collecting canal. The main collecting canal proceeds anteriorly upto the region of the posterior border of the oral sucker, makes a loop and runs upto the pharyngeal region, widens there and proceeds upto the region of intestinal bifurcation where it again becomes narrow and now runs posteriorly to open in the anterior chamber of the excretory bladder. The widened portion of the main collecting canal, on each side, is filled with 6–9, round to oval excretory granules of different sizes. The flame cells are arranged in doubles and thus the flame cell formula is $2(2 + 2) + (2 + 2) = 16$. A caudal excretory canal extends into the tail from the posterior end of the excretory bladder. At the posterior region of the anterior third of the tail, it gives off two small lateral canals, one on each side, which run towards the lateral margin of the tail and open to the outside. Then the caudal excretory canal proceeds posteriorly almost upto the distal end of the tail.

On crushing the infected snail, rediae came out from the hepatopancreas of the snail host. The rediae show slow movements of contraction and expansion. Numerous orange-coloured pigment spots are present all over the body of the redia. The rediae (Fig. 3) measure 0·810–1·230 mm. in length and 0·150–0·240 mm. in width in live specimens and 0·540–0·660 mm. in length and 0·120–0·135 mm. in width in fixed specimens. The muscular pharynx measures 0·052–0·124 mm. in diameter in live specimens and 0·048–0·064 mm. in diameter in fixed specimens. The gut is filled with blackish material and measures 0·255–0·345 mm. in length in live specimens and 0·168–0·224 mm. in length in fixed specimens. Birth pore is present at about 0·105–0·180 mm. from the anterior end of the body and the procuscula is at about 0·180–0·455 mm. distance from the posterior end of body. 3–12 well developed cercariae are present in each redia, besides which some cercariae are in developing stages. A few germ balls are also present in each redia.

Discussion

The present cercaria belongs to the "Echinatoides group" of Echinostome cercariae, which was created by Sewell (1922). Of all the species described under this group the present form resembles *C. indicae* XLVIII Sewell, 1922 ; *C. nairi*

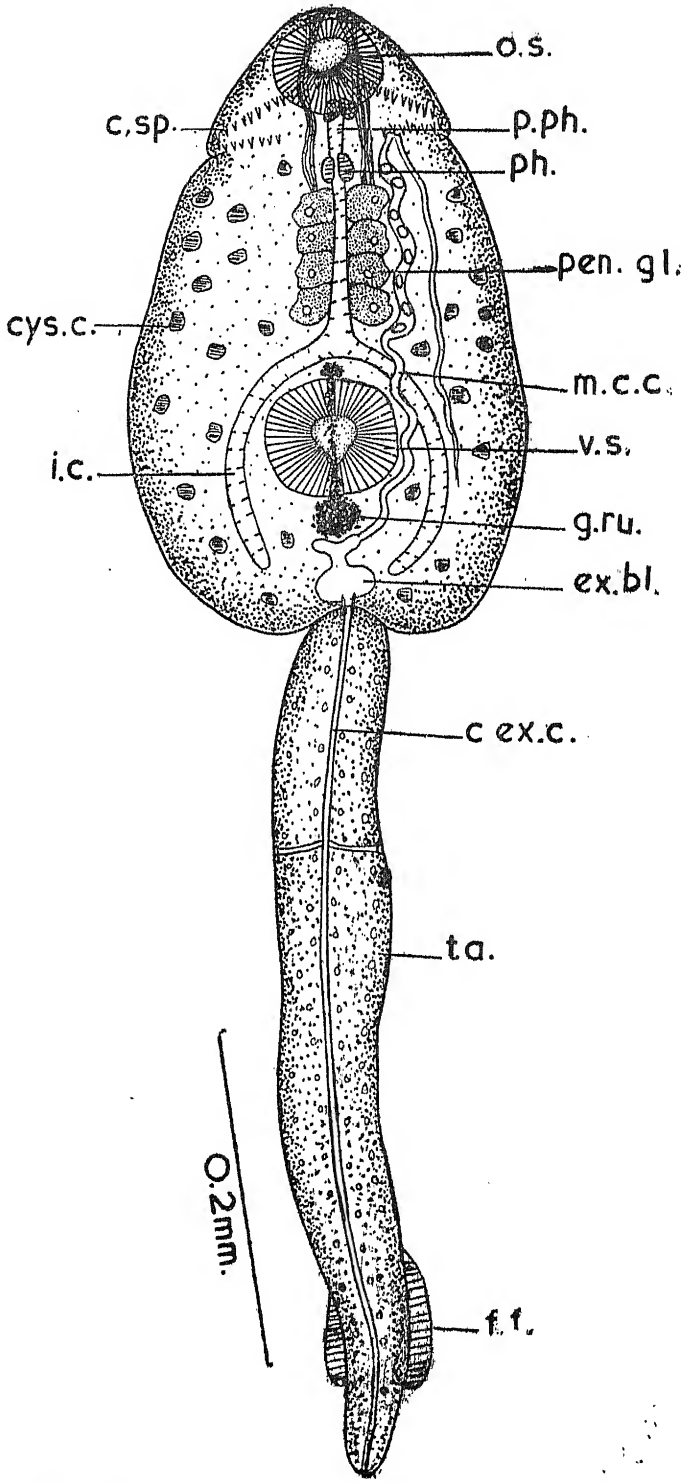

Fig. 1. *Cercaria tetraglandulata* n.sp. (spines on body and tail not shown).

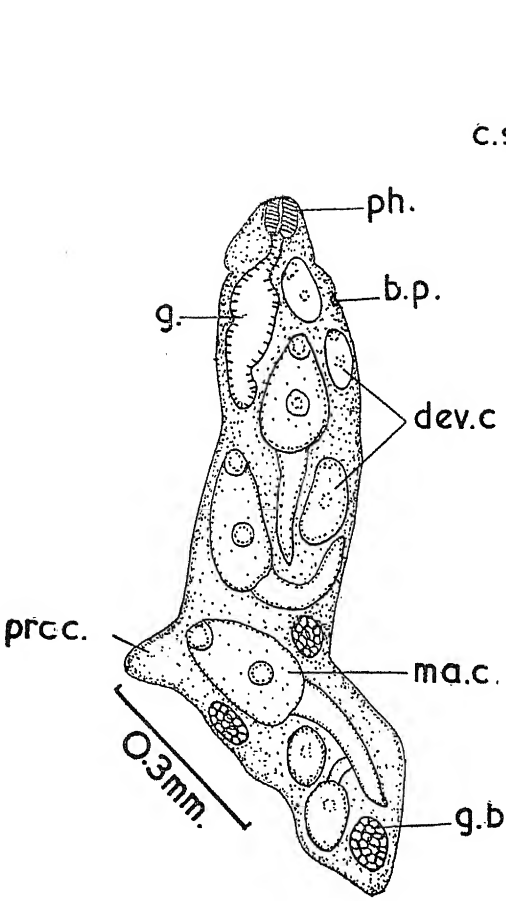

Fig. 3. Redia of *Cercaria tetraglandulata* n.sp.

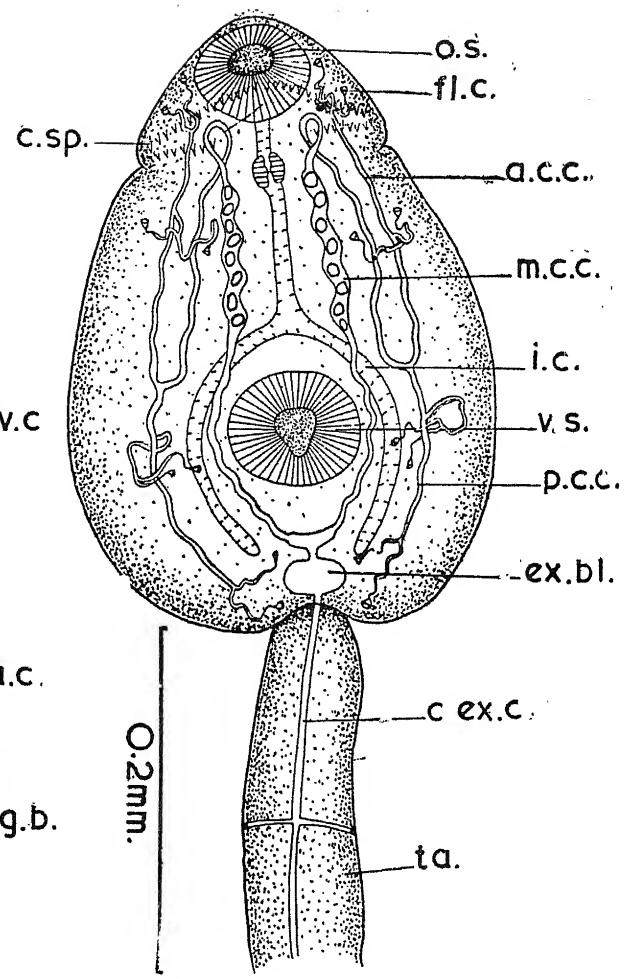

Fig. 2. *Cercaria tetraglandulata* n.sp. showing excretory system.

ABBREVIATIONS USED

a.c.c., anterior collecting canal ; b.p., birth pore ; c.ex.c., caudal excretory canal ; c.sp., collar spines; cys.c., cystogenous cells · f.f., finfold ; fl.c., flame cells ; g., gut ; g.b., germ balls ; g.ru., rudiments of gonads ; i.c., intestinal caecum ; ma.c., mature cercaria ; m.c.c., main collecting canal ; o.s., oral sucker ; p.c.c., posterior collecting canal ; pen.gl., penetration glands ; p.ph. ; prepharynx ; ph., pharynx ; proc., procuscula ; ta., tail; v.s., ventral sucker.

Peter, 1955 and *C. mainpurensis* Pandey, 1965. However, it differs from all these species by the number of collar spines and by the number of flame cells. From *C. indicae* XLVIII it further differs by the presence of the refractile dorsal body and by the excretory bladder being divided into two chambers. It can be distinguished from *C. nairi* and *C. mainpurensis* by the number of penetration glands. From *C. mainpurensis* it further differs by the absence of the cadual gland mass and the presence of both dorsal and ventral finfolds. This is, therefore, regarded as a new species and designated as *Cercaria tetragrandulata* n.sp.

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Vernalization and excised root growth in *Brassica campestris* L.

By

S. C. CHAKRAVARTI

S. S. L. Jain College, Vidisha (M. P.) India

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Introduction

Chakravarti (1964 *b*) while working with five Indian crop plants recorded that low temperature treatment of seeds brings about a decrease in the final output of dry matter of the entire plant as well as that of roots irrespective of the fact whether there is any early induction of flowering or not. The present investigation has been undertaken to determine whether this decrease in root growth results from the metabolites formed in the shoot or is independent of them.

Material and Methods

For the experimental purpose, general culture technique for excised roots of tomato used at Swansea by Street and his co-workers (Hanney and Street, 1954 ; Ferguson, 1958 ; Ferguson, Street and David, 1958) was adopted so that the growth of treated and untreated roots could be compared under strictly controlled conditions.

Seeds of *Brassica campestris* L., T. 151 were surface sterilised by immersion in a 0·5% aqueous Bromine solution for 2 minutes, washed thoroughly with sterile double distilled water and placed in sterile 9 cm. Petri dishes lined with moist filter paper (Whatman No. 1) containing about 2 ml. distilled water. These were allowed to germinate in dark at 27 ± 1°C. for 5 days to act as control. For vernalization, they after being kept for two days at this temperature were removed to a cold chamber maintained at 3 – 5°C. and left for 15 days. 10 mm. root tips of these and of controls were then excised and placed separately in 100 ml. Erlenmeyer Pyrex flasks containing 50 ml. of standard tomato culture medium adjusted to pH 4·9 which came down to 4·5 on autoclaving. Mouth of the flasks were plugged with cotton wrapped in fine cloth and covered with aluminium caps.

The medium was of White (1943) to which 0·0017 mg./l Molybdic acid and 0·013 mg/l Copper sulphate were added (Boll and Street, 1951). Growth factor consisted of Aneurin hydrochloride, 0·1 mg., Pyridoxine hydrochloride 0·1 mg., Nicotinic acid 0·5 mg. and Glycine 3·0 mg. per litre. For experiments of shorter duration (7 – 10 days) Ferric chloride 2·5 mg./l and for longer duration (21 days) Ferric ethylene-diamine tetra-acetate (giving a concentration of 1 ppm. of Fe in the final medium) was added as a source of iron. Concentration of Sucrose was maintained at 1·5% throughout the study. For certain experiments, the above medium was modified by the addition of Yeast extract (DIFCO Bacto Yeast), IAA and Kinetin.

After the incubation of the culture at 27° ± 1°C. for the desired period, roots were taken out and the length of the main axis (LMA), number of laterals or lateral initials (LN) and total length of the laterals (LL) were determined in all the experiments. For ones where a comparison has been made between the vernalized and control, in addition to the above, dry weight was also determined

and for this five roots each, selected at random, were taken together, blotted and placed in 5 lots in Aluminium foil bags and dried to constant weight in an oven maintained at 98°C.

Data and Discussion

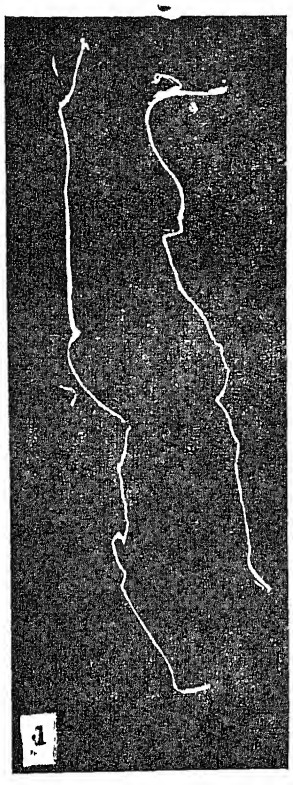
Attempt to cultivate *Brassica* roots in standard tomato culture solution, referred above, resulted in a failure as the 10 mm. root tips grew for 2 – 3 days only, after which the progress slowed down and finally stopped with an average main axis length of 55 mm. in 7 days incubation. These roots, devoid of laterals had a zigzag appearance (Fig. 1) and refused to be sub-cultured. This is interesting as under similar conditions tomato root main-axis has straight growth of 130 – 150 mm. with 30 – 35 well developed laterals (Thomas, Craigie and Street, 1963) with infinite capacity of sub-culturing. Failure to elongate and produce laterals in tomato roots occurs only when Sucrose is replaced by 2% Glucose in the media (Thomas, Craigie and Street, 1963).

Several experiments were then carried out to induce tomato type of growth in mustard by varying the composition of the media through additions of Yeast extract, which formed the sole growth factor in the experiments of White (1938) with excised roots of *Brassica nigra*, maintained through as many as 40 passages. For *Brassica campestris*, of the three concentrations – 100, 50 and 25 ppm. Yeast extract, the lowest one gave the maximum elongation of the main axis (Av· 250 mm.). There was profuse initiation of laterals in all the three but none grew beyond 1 mm , which was so even when the roots were allowed to grow for a period of three weeks and attain in certain cases as great a length as 520 mm. (Fig. 2). Addition of Yeast corrected the zigzag nature of the axis but failed to induce sub-culturing.

IAA and Kinetin were selected due to their known effects (Street and Winter, 1963) on the growth of the excised roots. They were added separately to the normal tomato solution modified by the addition of 25 ppm. Yeast extract. Data collected for the average length of the main axis LMA) and average number of laterals (LN) for the concentrations of 0·1, 0·01, 0·001 and 0·0001 ppm. of IAA and 0·012, 0·006 and 0·003 ppm. of Kinetin are produced in Figs. 3 and 4, a perusal of which would reveal that both IAA and Kinetin show a definite inhibitory effect on the length of the main axis at the highest concentrations used. This decreases gradually with a lowering in the concentration ; the lowest ones, IAA 0·0001 ppm. and Kinetin 0·003 ppm. bringing about a definite improvement over what is obtained with 25 ppm. of Yeast extract alone. Lateral number follows the same trend as that of the length of the main axis, showing thereby that their development is not affected by any of the treatments referred above. Both IAA and Kinetin have no effect on the length of the laterals.

There is no difference between the tomato culture solution and the ones modified by the addition of Yeast extract, IAA and Kinetin as regards sub-culturing. An increase in the length of root tips to 20 mm. too is without effect. Thus it would be seen that the excised roots of *Brassica campestris* L., T. 151 fall in line with many other species of plants whose growth factor requirements for continuous growth in culture await further investigation (Street, Carter, Scott and Sutton, 1961).

For a comparison of vernalized and control roots, the solution selected has been the normal tomato one with 25 ppm. Yeast extract. In view of the known effects of IAA on vernalization (Chakravarti, 1954, 1964*a* ; Chakravarti and Pillai, 1955) and there being no work on Kinetin with Indian plants, it was thought



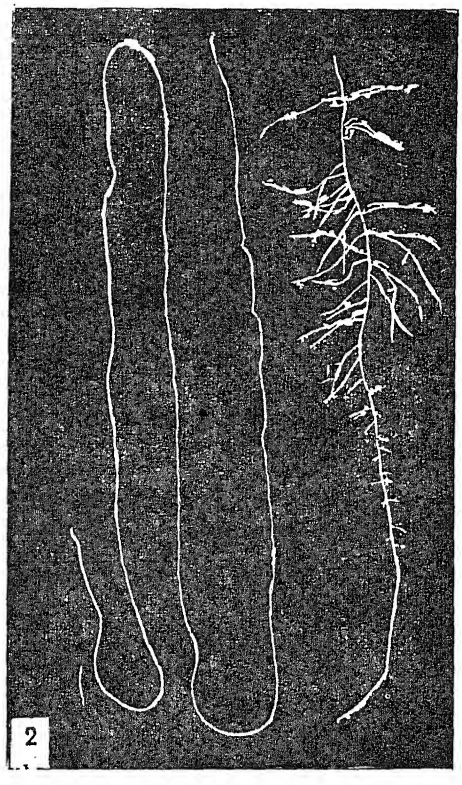


Fig. 1. Excised roots of *Brassica campestris* L., T. 151 after 7 days incubation in tomato culture medium. Note the zigzag nature of growth and absence of laterals.

Fig. 2. Left : An excised root of *Brassica campestris* L. T. 151 after 21 days incubation in tomato culture medium containing 25 mg./l Yeast extract. Length – 520 mm. Note the straight growth and initiation of laterals. Right: An excised root of tomato after 12 days of incubation in tomato culture medium.

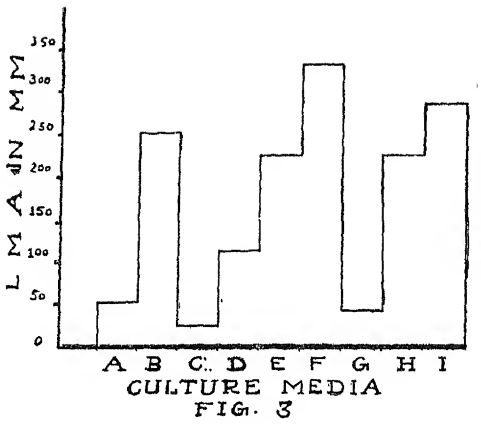


FIG. 3

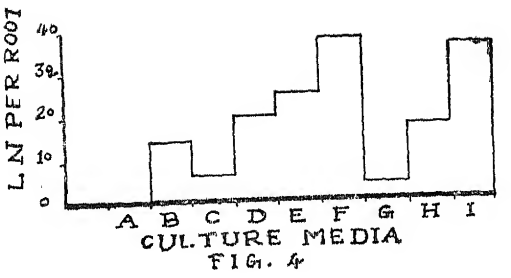


FIG. 4

Figs. 3 and 4. Length of the main axis (LMA) and number of laterals (LN) respectively of excised roots of *Brassica campestris* L., T. 151 incubated for 10 days in the following culture media.

A. Normal tomato solution.
B. A + Yeast 25 mg./l.
C. A + B + IAA 0·1 ppm.
D. A + B + IAA 0·01 ppm.
E. A + B + IAA 0·001 ppm.
F. A + B + IAA 0·0001 ppm.
G. A + B + Kinetin 0·012 ppm
H. A + B + Kinetin 0·006 ppm.
I. A + B + Kinetin 0·003 ppm.

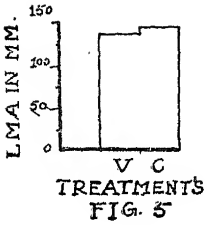


FIG. 5

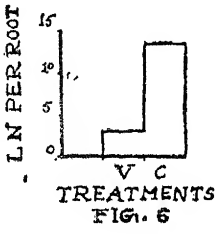


FIG. 6

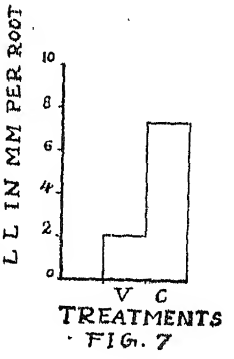


FIG. 7

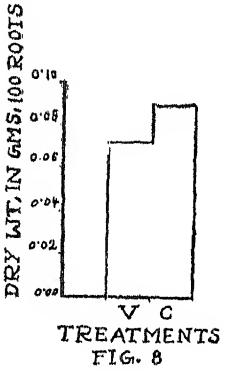


FIG. 8

Figs. 5, 6, 7 and 8. Length of the main axis (LMA), number of lateral (LN) length of laterals (LL) and dry weight respectively of excised vernalized (V) and control (C) roots of *Brassica campestris* L., T. 151 incubated for 10 days.

proper to avoid complications that might arise due to interaction of these chemicals with vernalin.

Of the several experiments showing practically similar results, the one reported here (Figs. 5 – 8) had 30 replicates of vernalized and 25 of control. A statistical analysis shows that with the exception of length of main axis other differences between the control and vernalized roots are significant at 5% level. Vernalization thus adversely affects the development of laterals on the main axis (Fig. 6) and their total length (Fig. 7) to which could be attributed the decrease in the dry weight of the treated roots (Fig. 8). From the data presented above, it could be concluded that in *Brassica campestris* vernalization brings about a decrease in the growth of the roots independently *i.e.* not by the way of metabolites synthesised in the shoots.

Summary

Present investigation has been undertaken to compare the growth of excised roots of *Brassica campestris* L., T. 151, raised from vernalized and control seeds.

To start with an attempt was made to determine a medium suitable for their growth. In 7 days incubation, in the standard tomato culture solution, they failed to grow beyond an average length of 55 mm. of the main axis, which was devoid of laterals and zigzag in appearance. Of the Yeast extract added to the above medium in the concentrations of 100, 50 and 25 ppm., the latter brought about the maximum improvement in the length of the main axis by raising it to an average of 250 mm. This also corrected the zigzagness of growth, induced profuse lateral formation (none, however, growing beyond 1 mm.) but failed to sustain sub-culturing which was true for all the other modifications of the nutrient medium used in the present studies.

Addition of IAA (0·0001 ppm.) and Kinetin (0·003 ppm.) to the standard tomato culture solution containing 25 ppm. Yeast extract resulted in a further increase in the length of the main axis but had no effect on the number and length of the laterals. Use of higher concentrations of both these chemicals had a growth depressing effect.

For a comparison of vernalized and control roots, the solution selected had been the standard tomato one modified by addition of 25 ppm. Yeast extract. IAA and Kinetin were avoided lest they may interfere with the effects of the chilling treatment. Vernalization has been found to bring about a statistically significant decrease in the number and length of the laterals and dry weight of the entire roots, the length of the main axis, however, remaining unaffected.

These experiments, though of a preliminary nature, indicate that growth depressing effect of vernalization in roots is independent of the metabolites formed in the shoots.

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Influence of Foliar Application of Nitrogen, Phosphorus and Potash on the Chemical Composition and yield of *Nicotiana tabacum* (Var. Harrison Special)

By

AMAR SINGH & O. S. SINGH

Department of Botany, University of Allahabad, Allahabad

(Received on 3rd Junuary, 1964)

Inorganic additives modify the chemical composition and final yield of tobacco leaves that form the main organs of commerical interest. The effect of inorganic additives applied to soil with respect to the chemical composition of tobacco leaves, has been studied by Garner (1951), Kadam *et al* (1954), Garmany (1955), Khemchandani *et al.* (1953), Krishnamurty *et al* (1954), Chandani *et al* (1959), Ramkrishna, Kurup and Sastry (1960), Gowaikar and Shaw (1961), and others in the past decade. Scientific evidances on the influence of foliar application of nitrogen, phosphorus and potash, both singly and in combination on the yield and chemical composition of tobacco leaves, are rather lacking. Apart from the need for the adjustment of time of application, dilution, quantity and nutrient to be applied as foliar spray, the real nature of the processes of absorption and translocation of the additives from the leaves remains to be ascertained.

Methods and Materials

Investigations were planned and executed to elucidate the influence of the application of nitrogen, phosphorus and potash, in different combination doses on tobacco leaves. Glazed pots containiug silica sand washed in accordance with recommendations of Hewitt (1947), were used for raising the plants. One month old seedlings of uniform size were transplanted @ one in each pot. Hoagland's complete solution was applied at the rate of 250 ml per pot weekly beginning a week after transplantation. Two concentrations each of (*a*) NH_4NO_3 *i.e.* $N_1 \equiv 0{\cdot}25$ M and $N_2 \equiv 0{\cdot}5$ M, (*b*) Ca $(H_2PO_4)\,H_2O$ *i.e.* $P_1 \equiv 0{\cdot}05$ M and $P_2 \equiv 0{\cdot}1$ M and (*c*) KCl *i.e.* $K_1 \equiv 0{\cdot}25$ M and $K_2 \equiv 0{\cdot}5$ M in eight combinations *viz.*, (I) $N_0P_1K_1$, (II) $N_1P_0K_1$, (III) $N_1P_1K_0$, (IV) $N_1P_1K_1$, (V) $N_2P_1K_1$, (VI) $N_2P_2K_1$, (VII) $N_1P_1K_2$ and (VIII) $N_2P_2K_2$, formed the treatments. These solutions were used four times at weekly intervals. A month after transplantation, when the foliage was well developed, plants were sprayed with these solutions using a hand sprayer. The process was repeated 4 times at weekly intervals. The pots were covered with a thick sheet of paper to avoid contamination of the sprayed nutrients with the sand substratum. The control set was simultaneously sprayed with distilled water. Fifteen leaves were maintained on each plant excluding the ground leaves. Each plant was sprayed with excess of distilled water before harvest to wash out the nutrients, if any, from the surface of the leaves.

At harvest, the leaf area was determined by a planimeter. Air dried leaves from each treatment were ground and passed through 22 mesh sieve aud analysed

for total nitro gen by the micro-Kjeldahl method. Nicotine was estimated by Avens and Pearce's method (1939). Total carbohydrate was determined by the method described by Loomis and Shull (1937). Calcium was estimated by micro method, and phosphorus and potash by colorimetric method (A. O A. C., 1950).

To strengthen the validity of the results, data were subjected to statistical analysis. Tests of significance of the treatments were found out by Fisher's (1950) method of analysis of variance.

Experimental Findings

Leaf Area : Promising effect of foliar application of leaf area was evinced (Table I). Higher concentration of nitrogen ($N_2P_1K_1$) brought about a significant increase in leaf size by 29·7 per cent over control and 10·2 per cent over lower concentrations of nitrogen, phosphorus and potash ($N_1P_1K_1$). Likewise, higher concentration of phosphorus in combination with lower doses of nitrogen and potash increased leaf growth by 22·0 per cent over control and by 3·7 per cent over $N_1P_1K_1$. Nitrogen, phosphorus and potash in a combination at higher concentrations ($N_2P_2K_2$) tended to increase the leaf size by 30·9 per cent over control and by 11·2 per cent over $N_1P_1K_1$. Lower concentrations in combination proved ineffective. Potash was found to be least effective even at higher concentrations (Table I).

TABLE I

Influence of foliar spray of nitrogen, phosphorus and potassium in combinations on the growth and expansion of leaves of Nicotiana tabacum at harvest

Treatments	Dry weight of leave (gm/plant)	Av. leaf area (sq. cm/leaf)	Av. length (cm/leaf)	Av. breadth (cm/leaf)
Control	20·45	180·39	28·10	10·57
$N_0P_1K_1$	18·82	170·13	28·22	10·63
$N_1P_0K_1$	20·98	205·36	28·60	10·51
$N_1P_1K_0$	22·93	218·56	29·55	11·28
$N_1P_1K_1$	22·43	212·27	28·28	10·58
$N_2P_1K_1$	27·96	234·00	29·77	21·41
$N_1P_2K_1$	26·02	220·10	29·18	11·12
$N_1P_1K_2$	22·80	210·26	28·40	10·51
$N_2P_2K_2$	28·28	236·19	29·62	11·48
S. E.	2·73	19·21	0·25	0·12
C. D. at 5%	5·36	37·65	0·52	0·25
C. D. at 1%	7·04	49·98	0·70	0·34

Leaf dimensions : Leaf area was increased by increase of its length as well as breadth, significantly so, in $N_2P_2K_2$, $N_2P_1K_1$, $N_1P_2K_1$ and $N_1P_1K_0$ treatments in descending order of responsiveness. Leaf breadth was influenced by the treatments to a greater extent than its length. Potash, at the two concentrations, in conjunction with nitrogen and phosphorus, proved ineffective in bringing about any change either in length or breadth of leaves (Table I).

Dry matter accumulation : Additive concentrations increased the dry matter accumulation in the leaves to a marked value (Table I). Nitrogen in two combinations of $N_2P_1K_1$ and $N_2P_2K_2$ proved significant and tended to increase dry

matter production by 24·5 per cent and 25·9 per cent respectively over $N_1P_1K_1$, 36·7 and 38·2 over the control. Higher concentration of phosphorus ($N_1P_2K_1$) also scored a significant mark and brought about 15·5 per cent increase over $N_1P_1K_1$ and 27·2 per cent over control. Potassium did not affect the dry matter accumulation significantly and lower concentrations of the three nutrients also proved ineffective.

Photosynthetic Efficiency : Three treatment combinations, *i.e.*, $N_2P_1K_1$, $N_1P_2K_1$ and $N_2P_2K_2$ raised the photosynthetic efficiency of the leaves significently (Fig. I). Administration of potassium, however, both in lower and higher concentrations, resulted in no significant change in photosynthetic activity which had manifested insignificant effects on leaf area as well as dry matter accumulation.

Nitrogen content : The effect of any of the three nutrient elements was more pronounced in conjunction with either one or the two remaining ones when compared to their lone effect. Higher concentration of nitrogen increased leaf nitrogen to a highly signifiant value. Contrary to the role of potassium for the above mentioned growth attributes, it influenced the nitrogen content of leaves positively, (Table II). Higher concentration of potassium in conjunction with nitrogen increased the nitrogen content significantly by 7·8 per cent. Phosphorus at both the concentrations in combination with potassium and nitrogen failed to effect any significant change in this respect.

TABLE II

The influence of foliar application of nitrogen, phosphorus and potassium in different combinations on the carbohydrate and nitrogen contents of the lamina of Nicotiana tabacum

Treatments	Carbohydrate (Total %)	Nitrogen (Total %)
Control	1·865	3·352
$N_0P_1K_1$	1·992	3·361
$N_1P_0K_1$	1·918	3·525
$N_1P_1K_0$	1·875	3·425
$N_1P_1K_1$	2·038	3·457
$N_2P_1K_1$	1·816	3·696
$N_1P_2K_1$	2·082	3·265
$N_1P_1K_2$	1·834	3·615
$N_2P_2K_2$	1·850	3·595
S. E.	0·007	0·062
C. D. at 5%	0·014	0·127
C. D. at 1%	0·019	0·173

Total carbohydrate : Carbohydrate accumulation was found to be affected as also nitrogen accumulation. Phosphorus along with lower concentrations of nitrogen and potash, increased carbohydrate content significantly (11·7 per cent) over control. Application of potassium and nitrogen at higher levels reduced the carbohydrate centent of the leaves (Table II).

Ash Content : Higher concentrations of nitrogen and phosphorus increased the ash content significantly. Lower concentration of phosphorus and nitrogen in the absence of potassium also increased it to a significant value. Beneficial effects of potassium were not in evidence (Table IV).

Nicotine Content : Highly significant increase in nicotine content was recorded when higher doses of nitrogen, phosphorus and potassium were used ($N_2P_2K_2$). Nitrogen, however, proved best to increase the nicotine content significantly higher, when its individual importance was evaluated (Table IV).

TABLE III

The influence of foliar application of nitrogen, phosphorus and potassium in combinations on the phosphate, potash and calcium status of the lamina of Nicotiana tabacum

Treatments	P_2O_5 (%)	K_2O (%)	CaO (%)
Control	0·430	1·352	7·345
$N_0P_1K_1$	0·410	1·365	7·115
$N_1P_0K_1$	0·425	1·342	6·853
$N_1P_1K_0$	0·475	1·405	7·756
$N_1P_1K_1$	0·443	1·342	7·075
$N_2P_1K_1$	0·452	1·425	6·271
$N_1P_2K_1$	0·485	1·343	6·943
$N_1P_1K_2$	0·425	1·440	6·664
$N_2P_2K_2$	0·460	1·410	6·308
S. E.	0·011	0·012	0·087
C. D. at 5%	0·022	0·024	0·179
C. D. at 1%	0·030	0·033	0·243

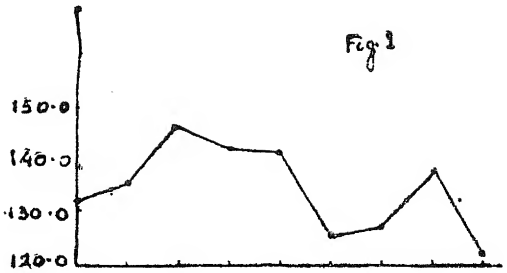
Phosphorus Content : Phosphorus application ($N_1P_2K_1$) increased its content in the leaves significantly. Nitrogen at its higher concentration also increased the phosphorus content to a marked value of significance. Potassium proved ineffective in this regard (Table III).

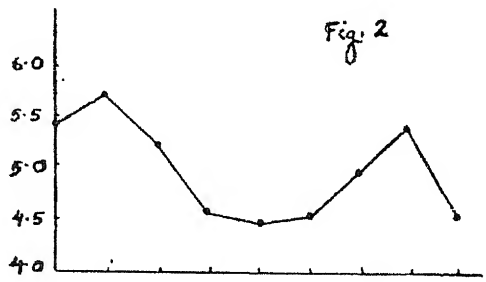
TABLE IV

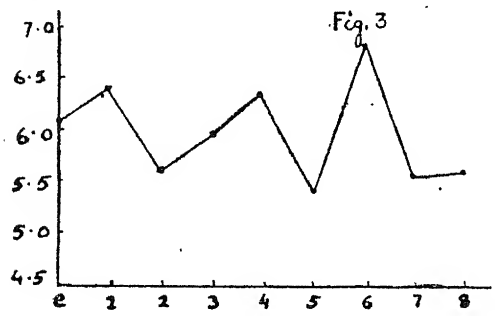
The influence of foliar application of nitrogen, phosphorus and potassium in combinations on the ash and nicotine level of lamina of Nicotiana tabacum

Treatments	Ash (%)	Nicotine (%)
Control	18·36	2·245
$N_0P_1K_1$	17·45	2·255
$N_1P_0K_1$	19·10	2·265
$N_1P_1K_0$	21 82	2·285
$N_1P_1K_1$	22·48	2·425
$N_2P_1K_1$	22·08	2·046
$N_1P_2K_1$	20 05	2·373
$N_1P_1K_2$	18·48	2·402
$N_2P_2K_2$	22·20	2·595
S. E.	0·45	0·016
C. D. at 5%	0·93	0·033
C. D. at 1%	1·26	0 045

Potassium Content : Potassium when applied with nitrogen spray increased its content in the leaves to a high level of significance. Phosphorus did not affect the potassium content of leaves (Table III).







Treatments

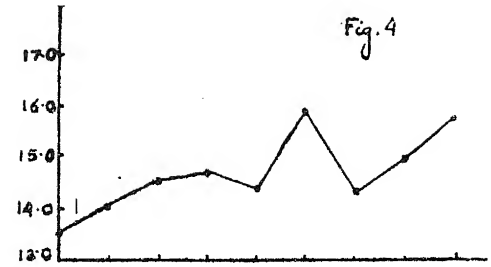
Influence of Foliar application on Tobacco
(per plant basis)

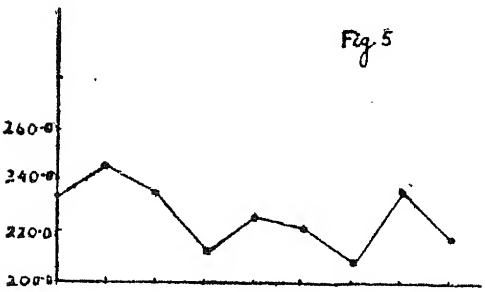
Fig. 1—Leaf area : dry weight

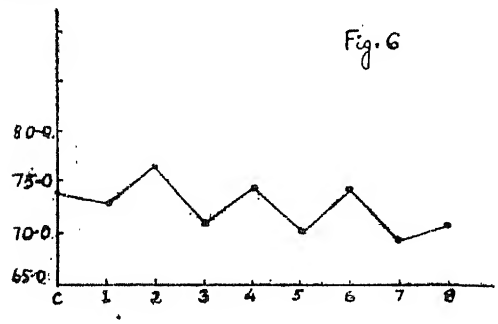
Fig. 2—Dry matter : ash

Fig. 3—carbon : nitrogen

Treatments : C-control ; 1-$N_0P_1K_1$; 2-$N_1P_0K_1$; 3-$N_1P_1K_0$; 4-$N_1P_1K_1$; 5-$N_2P_1K_1$; 6-$N_1P_2K_1$; 7-$N_1P_1K_2$; 8-$N_2P_2K_2$







Treatments

Influence of Foliar application on Tobacco
(per plant basis)

Fig. 4—Ash : CaO

Fig. 5—Ash : P_2O_5

Fig. 6—Ash : K_2O

Treatments : C-control ; 1-$N_0P_1K_1$; 2-$N_1P_0K_1$; 3-$N_1P_1K_0$; 4-$N_1P_1K_1$; 5-$N_2P_1K_1$; 6-$N_1P_2K_1$; 7-$N_1P_1K_2$; 8-$N_2P_2K_2$

Calcium Content : Significant reduction in calcium content in all the treatments, was observed with the spray. Greater reduction was tagged with higher concentration of nitrogen (Table III).

Discussion

Growth of plants, depended upon the surface area of leaf. Gregory (1917) and Watson (1947) considered leaf area as the main factor directly related with functions of definite physiological significance, especially its efficacy in increasing the dry matter accumulation in different parts of the plant through photosynthetic activity. It is an established fact that leaf area of plants, like other growth attributes, was greatly dependent upon the availability of nutrition through soil or foliar spray. It was evident that higher concentrations of nitrogen in $N_2P_1K_1$ and $N_2P_2K_2$ combinations and higher concentration of phosphorus in $N_1P_2K_1$ combination, showed greater photosynthetic efficiency (Fig. I). Thorne (1954) also reported a correlation between leaf area and dry matter accumulation in vegetable crops sprayed with nitrogen, phosphorus and potash. Fisher (1952) concluded that foliar sprays of nutrients could give yields as large or larger than equivalent soil dressings. Mentelaro *et al* (1952) and Silberstein and Wittwer (1951), by spraying tomato with nitrogen and phosphorus, recorded a greater increase in the yield than the application of similar amounts of nitrogen and phosphorus to the medium of growth.

Working with sugar beet and swedes, Thorne (1955) found a greater recovery of phosphorus than of nitrogen from leaf sprays as compared to fertilizer treatments to the soil. The results of these investigations with potassium in the nutrient spray, are in conformity with those of Thorne and Watson (1953) who reported that potassium content of the crop was increased significantly by spraying of potassium and neither leaf nor soil applications gave any increase in yield. They also reported that plants sprayed with solution containing nitrogen, phosphorus and potash, had higher nutrient contents and dry weight than control plants. The findings in these investigations point to the existence of a linear relationship between the nitrogen, phosphorus and potash application as spray and nitrogen, phosphorus and potash content of the tobacco leaves of the sprayed plants (Figs. 4, 5 and 6). A parallel mannerism was reported by Silberastein and others (1951), Isaacs *et al* (1953), Gattay *et al* (1957) and Barat and Das (1962), with several crop plants.

Tenderness resulting from nitrogen fertilization was stated by Lidfross (1907) due to change in the metabolic pattern of the plant with reduction in the sugar content accompanied by extra protein synthesis. Parallel findings are afforded in these investigations in the sense that nitrogen sprayed in higher concentrations increased protein content significantly and reduced carbohydrate content.

Nitrogen applied as spray enhanced the uptake of phosphorus from the medium of growth as was indicated by its significantly greater accumulation in the leaves. Thorne (1955) explained it as greater exposed leaf surface might have facilitated in the retention and absorption of much more nutrients from the spray so as to increase growth which, in its turn, increased the elemental content of the leaves not only by the absorption from the leaves but also through extra uptake by the roots. It was obvious that increase in phosphorus and potassium contents were the result of uptake from the culture medium due to the extra growth brought about by nitrogen in the spray (Figs. V and VI). On the other hand the uptake of other cations and anions may be depressed by the higher concentrations of cations and anions present inside the plant body. This was evident in the case

of calcium content of the leaves which was significantly reduced in each treatment (Fig. IV). These observations were contrary to those of Thorne (1955) who recorded an increase in calcium content by nitrogen spray on sugarbeets.

There had been a significantly higher accumulation of phosphorus and potash in plants sprayed with higher concentrations of these in combination with nitrogen (Figs. II, V and VI). Ash content was significantly higher due to the accumulation of inorganic salts in the sprayed plants.

An appreciable increase in nicotine content was noted due to the foliar application of nutrients. Hutcheson and Berger (1923) and Gowaikar and Shaw (1961) had recorded significant increase in nicotine content through soil application of nitrogen, phosphorus and potassic fertilizers.

Summary

The influence of foliar application of nitrogen, phosphorus and potash in varied concentrations, on yield and chemical composition of cigarette tobacco leaves (*var.* Harrison Special) was studied in sand culture.

Higher concentrations of nitrogen and phosphorus in the combination, were found to increase leaf area and dry weight of the leaves significantly.

Higher concentration of phosphorus was accounted for higher percentage of carbohydrate and ash and lower percentage of nitrogen. Higher concentration of nitrogen was found to increase the nitrogen and ash percentage and to decrease the carbohydrate content.

Phosphorus and potash contents were increased with higher concentration of phosphorus and potash as well as nitrogen in the spray. Calcium content was significantly reduced in each treatment concentrations.

Nicotine content in the leaves was appreciably increased through treatments.

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The length-weight relationship and K factor of *Gudusia chapra* (Hamilton) from the Ganga River system[1]

By

A. G. JHINGRAN[2]

Department of Zoology, University of Allahabad

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The determination of a precise mathematical relationship obtaining between length and weight of fish has numerous practical applications in fishery biology. With the help of the derived equation one measure can be converted into the other. According to 'cube law', the weight of a fish equals the cube of its length and can be mathematically expressed as

$$W = cL^3$$

where W and L are weight and length of the fish and c being a constant.

The above cubic relationship describes isometric growth as would characterise a fish having an unchanging body form and unchanging specific gravity (Ricker, 1958). As the form and specific gravity of animals are not constant due to changes affected in the body proportions during their life, the empirical observations do not stricitly conform to the cube law.

The departures from the general cube law relationship between length and weight have been variously utilized in fishery science to study environmental suitabilities, racial discriminations and the general well-being or robustness of fish by means of a condition factor (K factor, length-weight factor, coefficient of condition or ponderal index ; Hile, 1936 and Thompson, 1942). The present work embodies observations on the length–weight relationship of *G. chapra* together with the seasonal and annual fluctuations in K factor according to length, age, sex and maturity of the fish.

Material and methods

The total length and total weight data for 1,174 specimens, ranging from 50 to 200 mm in total length, were utilized for this purpose. The data used for computing the relationship for each sex separately were collected in course of five years (1958–62) during all months of the year with specimens in all stages of maturity. This eliminated any seasonal effect in weight due to differential feeding or maturity of gonads.

The data were grouped into sixteen size groups of 10 mm class interval. The average length and weight of each group was calculated and fitted into the formula

$$W = aL^n$$

1. A part of the thesis approved for the degree of Doctor of Philosophy of the University of Allahabad in 1966.
2. *Present address* : Central Inland Fisheries Research Sub-station, 30, Pannalal Road, Allahabad-2, (U. P.).

or logarithmically

$$\log W = \log a + n \log L$$

where

W = Weight of fish

L = Length of fish

a = A constant being the initial growth index

n = Equilibrium constant

The data were split under male and female and the length-weight curve fitted to the data by the method of least squares.

From the average weights of several specimens in 10 mm group, the average weight for each length group was computed for each month. These average weights were further used for computing K values for separate 10 mm length groups of both the sexes. Comparisions were also made of the average coefficient of condition calculated for individual years from 1958 to 1962. K was calculated from the following formula :

$$K = \frac{W \times 10^5}{L^3}$$

The number 10^5 was introduced to eliminate decimals and thus to bring K near unity.

Computation of length-weight formula

The equations that best describe the length-weight relationship in *G. chapra* were found to be

For males :

$$W = 0{\cdot}000010196\ L^{2{\cdot}97459}$$

or expressed logarithmically

$$\log W = -4{\cdot}99158 + 2{\cdot}97459 \log L \qquad (r = 0{\cdot}97616)$$

and for females

$$W = 0{\cdot}0000063194\ L^{3{\cdot}07422}$$

or expressed logarithmically

$$\log W = -5{\cdot}19933 + 3{\cdot}07422 \log L \qquad (r = 0{\cdot}92418)$$

The data for males and females were compared and it was found that the differences between the regression coefficients of males and females were not significant ($t = 0{\cdot}69148$, $d.f. = 1170$ at 5% confidence limit). Thus it was found desirable to pool the entire length-weight data, irrespective of sex, into a single equation. This general length-weight equation for *G. chapra* was calculated to be

$$W = 0{\cdot}97706\ L^{2{\cdot}96749}$$

or expressed logarithmically

$$\log W = -0{\cdot}01008 + 2{\cdot}96149 \log L\ (r = 0{\cdot}96796)$$

The length-weight relationship in *G. chapra* is delineated in Fig. 1. The curve represents the calculated weights and the dots the empirical weights. The agreement between calculated and empirical weights was generally good. The greatest discrepancies occurred among the larger fish for which the number of specimens was small.

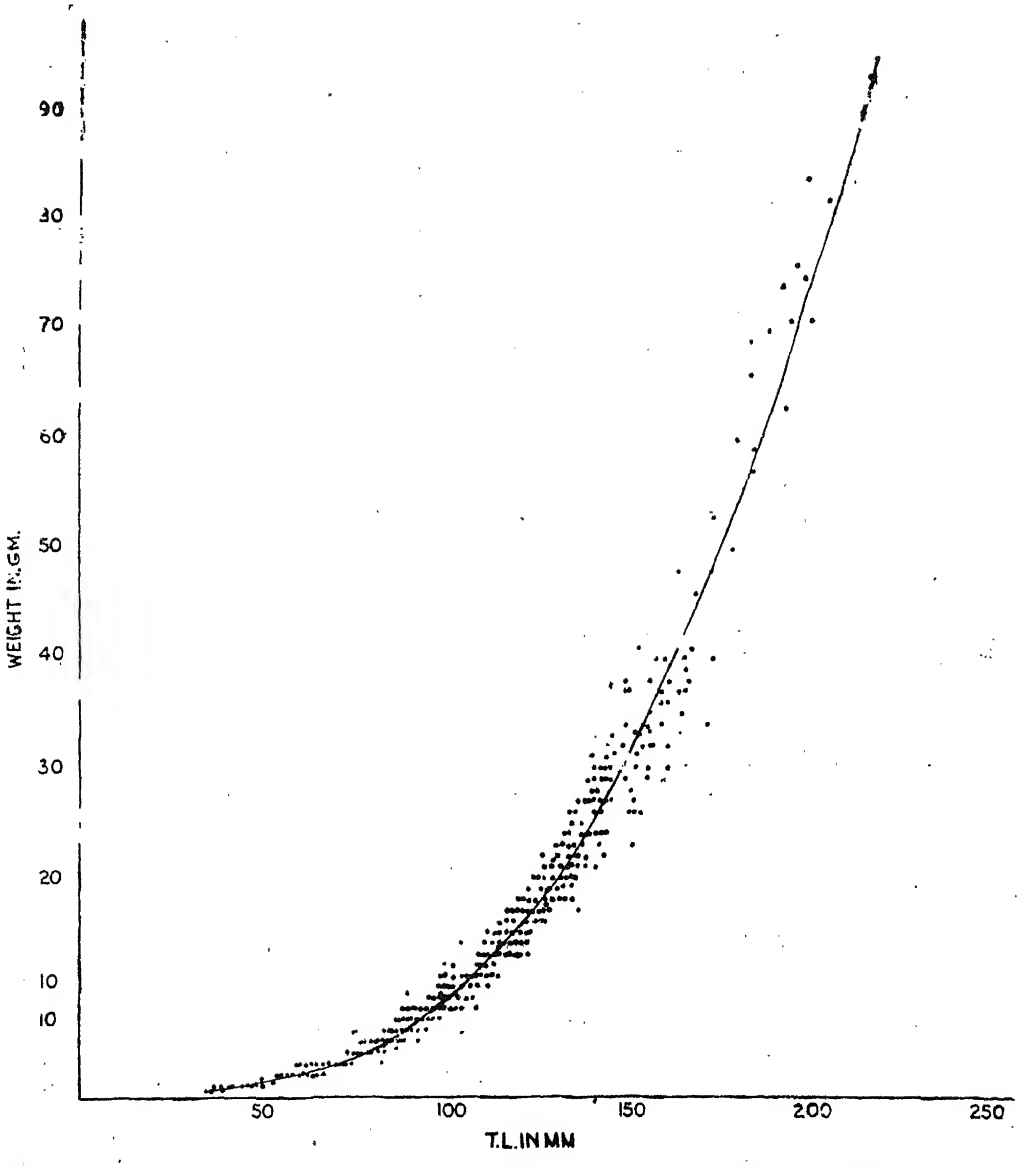

Fig. 1. Parabolic curve showing lenght-weight relationship in *G. chapra*

TABLE 1

Coefficient of condition (K) of G. Chapra according to age, month and year of capture

Month and year		Age groups I	II	III	IV	V	VI	VII	VIII	Average for the year
January	1958	0·89649	1·13028	1·12593	0·91116	0·91116	1·08820	0·87743	–	0·99152
	1959	0·89793	0·99458	1·13698	0·90683	0·99983	0·91322	0·90683	–	0·96517
	1960	0·68858	0·96318	1·03452	0·87445	0·02505	0·98627	–	–	0·98267
	1961	0·78582	0·88582	1·12259	0·95084	1·04980	0·96803	0·92160	0·87445	0·94487
	1962	–	0·87445	0·98584	0 95022	1·97861	1·01720	0·97464	0·78125	0·93747
Average for Jan.		0·81720	0·96966	1·08117	0·91870	0·99289	0·99459	0·92012	0·82785	0·95354
February	1958	0·90341	0·98627	1·04634	0·98627	1·05682	0·97656	0·87655	0·77052	0·95034
	1959	0·81114	1·08820	1.17547	–	-	0·97861	–	–	1·01336
	1960	0·90683	1·12259	0·93307	0·89743	0·99458	–	-	–	0·97090
	1961	0·98627	0·97861	1·13028	–	1·01250	0·92891	0·90422	0·78125	0·96029
	1962	0·77813	1·01725	1·05675	1·12260	1·04980	–	0·85926	0·72825	0·944580
Average for Feb.		0·87716	1·03858	1·06838	1·00210	1·02842	0·96136	0·85001	0·76000	0·96 78
March	1958	0·89743	1·09630	1·12598	0·97890	0·91116	0·87517	–	0·70925	0·94202
	1959	0·92662	1·02309	1·13698	0·94999	0·85926	0·90422	0·83483	0·69621	0·91640
	1960	0·75131	1·02013	1·09431	0·86997	0·91322	–	–	0·69955	0·89142
	1961	0·65276	1·00881	1·03452	0·91120	1·02505	0·90683	0 82644	0·62807	0·87431
	1962	0·70472	0·97700	1·05003	0·95055	0·98627	0·95002	0·79117	0·65741	0·88349
Average for March		0·78657	1·02507	1·08835	0·93212	0·93899	0·90906	0·81748	0·67826	0·90151

April	1958	0·72008	0·75230	0·79621	0·69955	0·75233	0·80000	0·70888	0·59622	0·72845
	1959	0·78125	0·65276	0·69955	0·79621	0·65276	0·62887	0·75762	–	0·70986
	1960	0·73260	0·75131	0·70925	0·72825	0·75131	0·77052	0·62835	0·60875	0·71004
	1961	0·68713	0·73467	0·73371	0·78125	0·73467	0·72918	0·61775	0·68822	0·71332
	1962	0·62320	0·62887	0·75234	0·71997	0·70472	0·81020	0·62891	0·71179	0·69750
Average for April		0·70885	0·70398	0·73821	0·74505	0·71916	0·74775	0·66830	0·65174	0·71183
May	1958	0·77671	0·75230	0·62880	–	0·73406	0·74500	0·62160	0·59888	0·69391
	1959	0·72755	0·78845	0·65394	0·79621	0·83483	–	0·79397	–	0·76577
	1960	0·79981	0·70082	0·73406	0·72825	0·77745	0·75394	0·68822	0·70925	0·73647
	1961	–	0·74661	0·78962	0·87464	–	–	0·72825	0·69955	0·76773
	1962	0·72507	–	0·74458	0·78540	0·78609	0·74897	0·70925	–	0·74989
Average for May		0·75728	0·74704	0·71020	0·79612	0·78303	0·74930	0·70826	0·66923	0·74275
June	1958	0·76052	0·83285	0·90000	0·87743	0·84290	0·78194	0·80996	–	0·82937
	1959	0·78125	0·83850	0·92891	0·90422	0·84999	0·85413	–	0·73371	0 84153
	1960	0·70925	0·83483	0·91514	0·89983	0·82644	0·78609	0·79117	–	0·82325
	1961	0·72448	0·79383	0·88582	0·92891	0·80000	0·78125	0·77052	0·70925	0·79926
	1962	0·73371	0·82304	0·99383	0·90683	0·85414	–	0·78125	0·79955	0·82748
Average for June		0·74184	0·82461	0·92474	0·90344	0·83469	0·80085	0·78822	0·71417	0·82418
July	1958	0·78194	0·83962	0·84360	0·81125	0·82501	–	0·84999	–	0·82555
	1959	0·77638	0·80979	0·58934	0·82900	0·84440	0·84414	0·83850	–	0·79022
	1960	0·72755	0·90097	0·73922	–	0·80282	0·80000	0·85926	0·72825	0·79401
	1961	0·82305	0·74940	0·85410	–	0·80997	0·83962	0·88582	0·87467	0·83380
	1962	0·84144	0·89611	0·82820	0·82305	0·83962	0·85741	0·77052	0·77052	0·82961
Average for July		0·79007	0·83918	0·77290	0·82111	0·82438	0·83529	0·84082	0·79115	0·81458
August	1958	0·77517	0·80458	0·81116	0·90422	0·86318	–	0·80997	0·78125	0·82136
	1959	0·77433	0·78445	0·85926	–	–	–	0·91121	0·84290	0·83443
	1960	0·78627	0·85022	0·91322	0·87743	0·90422	0·78609	0·88611	0·83820	0·85522
	1961	0·70422	–	0·80250	0·79117	0·82644	0·83483	0·74940	–	0·78476
	1962	0·71116	0·89175	0·84098	0·90422	0·90422	0·89793	0·77455	–	0·84640
Average for August		0·75023	0·83275	0·84542	0·86926	0·87451	0·83962	0·82625	0·82078	0·82843

Month and year		Age groups I	II	III	IV	V	VI	VII	VIII	Average for the year
September	1958	0·64281	–	0·81630	0·82880	0·91116	0·87743	–	–	0·81530
	1959	0·71714	0·78692	0·83820	–	–	0·82002	0·83850	–	0·80016
	1960	0·73802	0·80000	0·84290	–	0·89983	–	0·77052	0·79671	0·80800
	1961	0·73333	0·81455	0·91220	–	0·86042	0·80996	–	0·73891	0·81153
	1962	0·68905	0·90662	–	0·80000	0·83285	0·83275	–	0·72160	0·79714
Average for Sept.		0·70407	0·82702	0·85235	0·81440	0·87606	0·83504	0·80451	0·75241	0·80642
October	1958	0·81920	0·87891	0·91321	0·86482	0·90096	0·83762	0·89743	–	0·87316
	1959	0·89012	0·84999	–	0·86482	0·89748	–	0·77052	0·31417	0·84785
	1960	0·75022	0·86797	0·95055	0 89983	0·83820	–	0·70472	0·75231	0·82340
	1961	0·77052	0·91120	0·89163	0·91120	0·58309	0·77117	–	0·70472	0·79193
	1962	0·73467	–	0·94496	0·81920	0·81417	0·75230	0·65276	0·58309	0·75731
Average for Oct.		0·79295	0·87702	0·92509	0·87197	0·80678	0·78703	0·75636	0·71357	0·81873
November	1958	0·73371	0·84360	0·85414	0·90925	0·97445	0·89793	0·88405	0·87445	0·87145
	1959	0·79261	0·95022	0·88113	0·92887	0·88045	–	0·90683	–	0·89002
	1960	0·75234	0·88200	0·90925	–	–	1·04634	0·93285	–	0·90456
	1961	0·76800	0·87445	0·99955	–	0·97861	–		0·83285	0·89069
	1962	0·85413	0·90683	0·92887	0·95022	0·99793	0·99860	0·97052	0·90000	0·93839
Average for Nov.		0·78016	0·89142	0·91500	0·92945	0·95786	0·98096	0·92356	0·86910	0·89902
December	1958	0·84360	0·88045	0·87517	0·97656	0·82644	0·98627	0·91322	0·99649	0·91227
	1959	0·87517	0·87447	0·98627	0·90683	0·98627	0·89983	0·85926	0·87743	0·90819
	1960	0·87618	0·94084	0·90422	0·91116	0·90683	1·08320	0·91322	0·82644	0·92089
	1961	0·82304	0·87445	0·90683	0·97860	0·98045	0·97656	0·98211	–	0·93172
	1962	0·77117	0·95022	0·86482	0·95022	0·84360	0·83962	0·82644	–	0·86373
Average for Dec.		0·83783	0·90409	0·90746	0·94467	0·90872	0·95810	0·89885	0·90012	0·90736

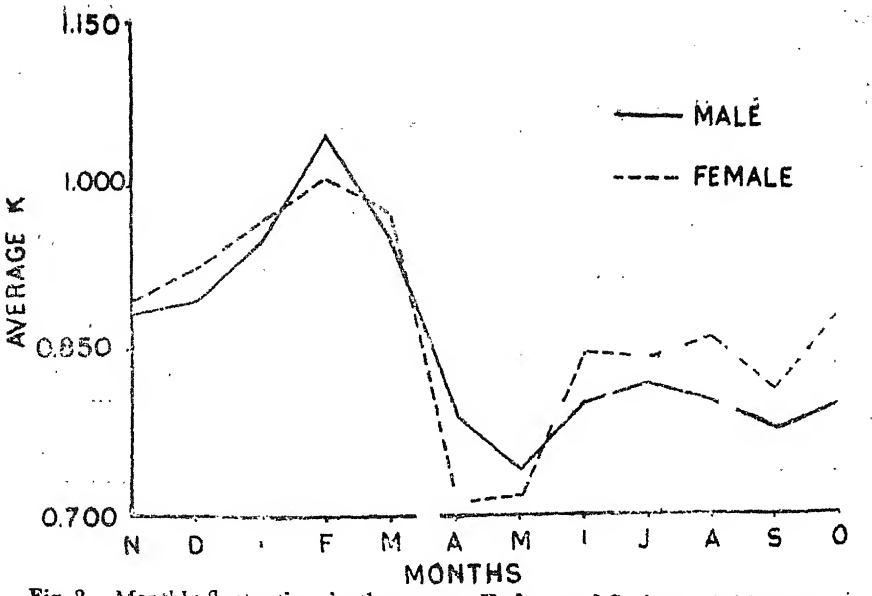

Fig. 2. Monthly fluctuations in the average K. factor of *G. chapra* of either sex.

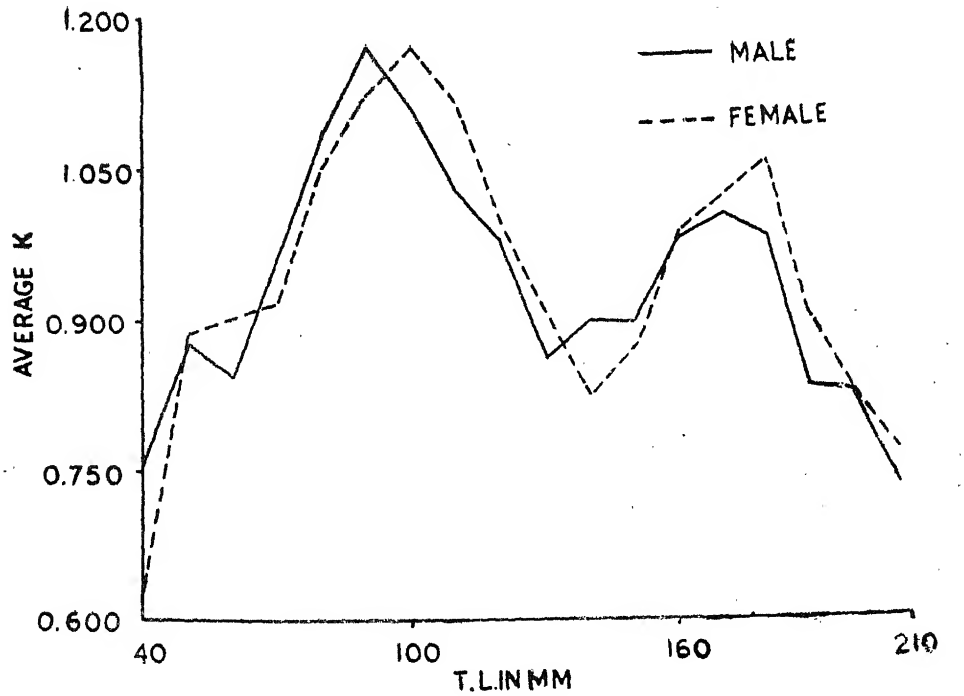

Fig. 3. Average K. factor in relation to length of *G. chapra* of either sex.

K Factor

(*i*) *Monthly fluctuations*

The averages of the K factor were calculated for each month of the five years (1958 to 1962) represented in the data. The results are shown in Table I. The monthly grand averages for the entire five-year data are graphically depicted in Fig. 2 separately for males and females.

The general trend of the fluctuations in K, as shown in Fig. 2, indicates that January registered high values both for males as well as females after which a decline in the value occurred. The mean K values remained low until July. The lowest values of K were observed during April and May for both the sexes. These two months encompass the peak spawning period of the fish. The monthly averages in Table I show that this April-May decline in K values was more pronounced during the years 1959 and 1962. In August, an improvement in condition was observed after which the average K again decreased slightly in September and underwent a greater decrease in October. A recovery was again noticed in November and thereafter, both the sexes were seen in a better condition in December (K = 1·13683 for males and 1·09116 for females). The grand averages of K, obtained from corresponding months of five years, are depicted in Table II.

TABLE II

Average monthly values of K for the whole five-year sample

Months	Male	Female
N	0·98113	0·95414
D	1·13683	1·09116
J	1·17547	1·13028
F	1·12259	1·01725
M	1·05003	1·09452
A	0·73467	0·70472
M	0·78194	0·70925
J	0·84360	0·87455
J	0·81417	0·83820
A	0·97700	0·96318
S	0·94022	0·92662
O	0·89983	0·91321

From Fig. 2 certain trends in the monthly fluctuations of K value can be detected for either sex. The males showed a steady increase in K from October onwards, reaching a maximum in January (K = 1·17547) after which there was a gradual fall. From April to July, the values consistently showed a lower level of condition, especially during April and May.

In females too, the fluctuations in K value followed a similar pattern. From October onwards the K values recorded a steady increase, attaining the highest value (1·09452) in March after which an abrupt decline in the value (K = 0·70472) occurred. In females also the K values oscillated at a low level between April and October.

(*ii*) *Annual fluctuations in K value*

In addition to the fluctuations in K value from month to month, the values also varied from year to year. Table III depicts the grand averages for K in the different year's collections from 1958 to 1962. The copious data collected during

the course of five years and presented in Table I compares the average K for corresponding months of each of the five years. This comparison from Table I reveals that the general condition of the fish during January, March, April, September and October was slightly better in 1958 than that observed in rest of the four years from 1959 to 1962. Recording high mean values of K in February (1·01336) and June (0·84153), 1959 overshadowed other years. In May and July, 1961 recorded higher values of K. The August average was higher in 1960 whereas 1961 and 1962 recorded high K values in December and November respectively.

However, when grand averages for different years were compared, the general order with respect to the condition of *G. chapra* from best to poorest was : 1962, 1961, 1960, 1958 and 1959.

TABLE III

Comparison of grand averages of K from 1958 *to* 1962

Year	Average K
1958	0·85453
1959	0·85691
1960	0·84724
1961	0·84202
1962	0·83941

(*iii*) *Fluctuations in K in relation to length of fish*

The average values of K in relation to the length of fish of either sex are given in Table IV and plotted in Fig. 3, separately for males and females. From the above figure it is evident that the value of K remained relatively low in smaller length groups but gradually a good condition was built up and the highest value was attained at a mean length of 90 mm in males (K = 1·17547) and at 100 mm in females (K = 1·17315). After this, a gradual fall in the K values was noticed. This decline continued upto 130 mm total length in males and 140 mm in females. Thereafter, again a steady increase in the K values occurred. The K values again registered a fall, attaining, at a mean total length of 210 mm, low values of 0·73467 for males and 0·78125 for females.

(*iv*) *Fluctuations in K value with age*

Data pertaining to variations in K with respect to the age of fish, as observed during different months of the years 1958 to 1962, are presented in Table I. With a view to minimizing the effects of monthly and annual fluctuations in K, each month's collections were averaged. The table also comprises the grand averages of K at each age during all the five years of investigation. Though the data do not depict any marked dependence of K as the age of fish, certain well-defined trends are noticeable. Age group I had low average K ranging between 0·70407 in September and 0·87716 in February. However, in April and May the K values of age group I were observed to be higher than those of age group II. Average K values were seen to rise steadily from age group I onwards till they attained the highest value mostly in age group III. Except in May and July, the K values of age group III were higher than those of age group II. In age groups IV and V the fluctuations in K occurred around a mean level changing from year to year and in different months of the year. The averages for different corresponding months of the five years showed that the K values remained higher in age group IV

during the months April, May, October and December, when compared to those recorded for age group V, while the latter age group had higher K values in the rest of the months. The two age groups had almost similar values of K in March, July and August. From the 49 comparative values of K recorded in Table I for these two age groups, no significant pattern of their fluctuations could be made out. After age group IV, the K values again declined with increase in age, registering the lowest values in age group VIII.

TABLE IV

Sex-wise average K for individual length groups of G. chapra

	Male	Female
40	0·75267	0·62646
50	0·87743	0·88582
60	0·84450	0·89895
70	0·96318	0 91514
80	1·08820	1·05675
90	1·17547	1·13028
100	1·11212	1·17315
110	1·02576	1·112.)2
120	0·97861	0·99383
130	0·86482	0 90422
140	0·90006	0·82645
150	0·90000	0·87412
160	0·98267	0·99458
170	1·00667	1·02505
180	0·98800	1·06612
190	0·83820	0·90683
200	0·83762	0·77052
210	0·73467	0·78125

Discussion

According to Hile (1936), the equation $W = aL^n$ expresses the relationship better than the general cube law. The logarithmic expression of this formula gives a straight line and the values of log a and n are computed from the following normal equations :

$$\log a = \frac{\Sigma \log W. \Sigma (\log L)^2 - \Sigma \log L (\Sigma \log L. \log W)}{N. \Sigma (\log L)^2 - (\Sigma \log L)^2}$$

and

$$n = \frac{\Sigma \log W - N \log a}{\Sigma \log L}$$

The relationship $W = aL^n$ has been used by a host of workers on different fishes (Jarvi, 1920; Clark, 1925 and 1928; Tjurin, 1927; Van Oosten, 1929 and 1942; Fraser, 1931; Hart, 1931 and 1932; Tester, 1932; Walford 1932; Schultz, 1933; Foerster, 1936; Hile, 1936 and 1941; Hile and Jobes, 1941; Beckman, 1942, 1945 and 1949; Marr, 1943; Khan and Hussain, 1945; Jobes, 1952; Jhingran, 1952; Sarojini, 1957; Pillay, 1958; Pantulu; 1961, 1962 and 1963; Varghese, 1961 and Natarajan and Jhingran, 1963). This relationship indicates that the weight of a fish varies as some power of its length.

Beverton and Holt (1957) discussed the relative merits of both the equations and pointed out the superiority of the second equation ($W = aL^n$) only when purely empirical representation of the data was needed. According to them if $W = aL^n$ is fitted, the values of a and n vary within wide limits for very similar data, and prove sensitive to even quite unimportant variations in n.

A perusal of the length-weight equations derived for *G. chapra* indicates that except in females where the value of n was found to be very close to 3 (n=3·07422) thus satisfying the cube law, the value of n for males was below 3 (n = 2·97459) and so was the case with the general length-weight equation for males and females combined (n = 2·96749). Since the value of n is below 3 in the general length-weight equation it may be inferred that the weight of *G. chapra* increases slightly less than the cube of its length. The slightly greater value of n in females may be attributed to anisometric growth of the ovaries as Riatt (1933) observed in the haddock. The monthly K values are known to be influenced mainly by the following factors :

1. Maturity of gonads
2. Amount of undigested food in the alimentary canal
3. Changes in the amount of fat stored in the body tissues.

In *G. chapra* the K values showed a decline after attaining a peak value in January. A gradual decline in K followed thereafter. In April the K values abruptly declined and remained at a low ebb till July. This decline in K values from April denotes the beginning of the spawning activity in *G. chapra*. The extremely low values of K recorded from April to July coincide with the peak spawning period of the fish. These observations are in fair agreement with those of Cunningham (1891). After undergoing a short recovery in August, the K values again dropped in September, though this decline was of a lesser degree as compared to that observed during the peak spawning period of the fish. This might be explained by the fact that spawning in *G. chapra* is accomplished in more than one unrythmic spawning bursts. It is probable that the samples collected during September comprised those individuals which had shed a few batches of ova and resorted to active feeding to overcome the strain of discharging bulk of reproductive products. Such individuals, therefore, showed higher K values in comparison to those still engaged in spawning activity. Furthermore, it is likely that comparatively more sexual products are mobilised in the initial and peak spawning phases than in the later part of the spawning period. This may explain the relatively higher values of K observed in September which represents the later period of the spawning season of *G. chapra*.

The food analysis of the species depicted three feeding phases in the life history of the fish, *viz.* a period of subdued feeding coinciding with the spawning period and two phases of active feeding, one each during the pre- and post-spawning periods. The K values are seen to be low during the phase of subdued feeding and high during the periods of active feeding.

The fluctuations in K value, related to increase in length of the fish, have been employed by various workers (Hart, 1946 ; Menon, 1950 ; Pillay, 1958 and Natarajan and Jhingran 1963) to determine the size at which fishes attain their sexual maturity. Hart (*op. cit.*) observed :

> "..... There is a lower level of condition throughout the seasonal cycle consequent upon the increased metabolic strain of spawning. The

point of inflexion on a curve showing this diminution of K with increasing length is thus a good indication of the length at which sexual maturity is attained."

This inflexion point in *G. chapra* was found to be at 90 mm for males and 110 mm for females. The studies on the maturity of fish have revealed that 50% of females *G. chapra* mature at 110 mm which substantiates the above observation.

The data in Table I do not pinpoint any marked dependence of K on age. Higher values of K occurred in age groups II to V which were well represented in the catches. The low values of K were frequently recorded for age group I. The growth studies have indicated that the fish has its fastest growth during the first year of its life. It is possible that at this age the metabolic changes in the fish tend more towards the increase in linear dimension than towards building up weight. Thus during this period more energy is utilized towards expansive growth than towards the maintenance, thus lowering down the K.

Summary

Computation of length-weight equation for *G. chapra* revealed that the differences in the exponential indices of length in males and females were statistically not significant. A general length-weight equation, derived for both the sexes indicated that the weight of this species increases slightly less than the cube of its length.

In *G. chapra*, the inflexion point on the K-curve, drawn at various fish lengths for either sex, gave the size at maturity of the fish. K was found to be independent of age though its values remained high among the age groups (II to IV), best represented in the commercial catches. The lowest values of K were recorded during April and May which represented a period of subdued feeding and active spawning of the fish. The fish was observed to be in its poorest condition in 1959 and best in 1962.

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Histochemical studies on the brain of certain Teleostean fishes. I. Pigments-Lipofuschin

By

B. M. SINHA *and* P. K. SAXENA[1]

School of Studies in Zoology, Vikram University, Ujjain

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Introduction

Most of the reported work on neurohistochemistry deals with the mammalian tissue. The present work undertakes the study on the localization of lipofuschin granules in the brain of fishes, *Notopterus notopterus* (Pallas) and *Puntius ticto* (Gunther). The lipofuschin pigment has been studied by Pilcz (1895), Muhlmann (1901), Obersteiner (1904), Wolf and Pappenheimer (1945), Einarson (1953), Dixon (1955), Hyden (1955), Sulkin (1955), D'Angelo, Issidorides and Shanklin (1956), Gedigk and Bronte (1956), Shanklin, Issidorides and Nasser (1957), Deane (1958), Nasser, Issidorides and Shanklin (1960), Sulkin and Srivany (1960) and Issidorides and Shanklin (1961) in mammals; Sharma (1961) in reptiles and Singh (1963) in aves. The pigment occurs in the form of localized granules and is said to increase in man with age. The chemistry and metabolic significance of this pigment in the neurons are still very much obscure (Pope and Hess, 1957), although some physiological role has been assigned by Issidorides and Shanklin (1961) and it is considered as a waste product of neurons by Dixon (1955).

Material and Technique

The brains were exposed in alive specimens and taken out immediately after pouring the fixative over them. They were kept in fixative for twenty-four hours and thereafter longitudinal sections were obtained at 8-10 μ thickness. The sections were subjected to chrome alum haematoxylin (Gomori, 1941) and nile blue sulphate (Hueck, 1912) techniques given by Pearse (1961) to stain only the lipofuschin granules.

Observations

Chrome-alum haematoxylin :

In *Notopterus* most of the neurons throughout the brain are found to be positive, while the fibres and interstitial tissue are negative though sometimes they tend to take a very light colouration at certain places.

In the olfactory bulb, the positive neurons are scattered throughout, but they are more aggregated in its peripheral region. In the neurons only their perikaryonal region is deeply stained and in a few the positive reaction extends into the processes (axon and dendrites) as well. The olfactory tract shows deep staining in the nuclear region of neurons instead of perikaryonal region. In axial lobe of cerebrum, the positive neurons stain deeply in the perikaryonal region, except for a few which get almost fully stained. The peripheral positive neurons are shrunken and stained lighter than the central ones and the intensity of reaction increases from the peripheral to the central region. In infundibulum, the aggregation of positive neurons occur around the infundibular recess (Plate I-1), besides being sparsely scattered in the remaining region. Its positive neurons

1. Department of Zoology, Punjab Agricultural University, Ludhiana (India).

show mostly the nuclear region deeply stained, although neurons with the perikaryonal region stained have also been observed. In the inferior lobe, the positive neurons are uniformly distributed with little aggregation in the centre around its ventricle (Plate I–2). The neurons show positive staining mostly in the nuclear region only. In saccus vasculosus (Plate I–3. the positive reaction has been noticed in the nuclear region of cell body and apical protrusion of coronet cells, though the former region is better stained. The hairs and globules of coronet cells react very lightly and are rarely found to be positive. The supporting cells between the coronet cells and wall of loculi, however, show a very deep staining. The neurons of tectum opticum (Plate I–4) show deep staining in the nuclear region and exhibit aggregation on either side of intertectal commissural zone (Plate I–5), which is negative. The ventricular ependymal layer shows distinct staining on the inner free marginal side. In torus longitudinalis, the positive neurons show reaction in their nuclear region. They are accumulated in the lower part and gradually decrease towards the upper side. In torus semicircularis, the neurons display positive reaction in the nuclear region mostly, although in a few cases the perikaryonal region is also positive. The positive neurons are arranged in a layer immediately below the free upper surface.

In cerebellum (Plate I–6 and 7) the neurons of granular layer and intracerebellar nucleus are deeply stained in the nuclear region. The Purkinje cells are deeply stained in perikaryonal region and in processes the intensity of staining increasing in the region of process towards the cell. In the neurons lying above the Purkinje cells, only the nuclear region is found to be stained. In medulla, the neurons are mostly stained in the nuclear region, although in a few large neurons the staining has been observed throughout (Plate I–8). In somatic sensory lobe, the positive neurons are confined to subcortical layer, while in the facial and vagal lobes they are present at the dorsal periphery and in a layer below separated by a non-stained area.

The extracellular lipofuschin granules have been noted in interstitial tissue and between the optic nerve fibres, which react similar to the olfactory tract, although the connective tissue sheath of the optic nerve is stained very lightly. The blood vessels show light staining in their walls and deep staining in the nuclear region of blood corpuscles (Plate I–4).

In *Puntius*, the positive reaction has been noticed mostly in the nuclear region of neurons although light staining in the perikaryonal region of neurons in the infundibulum and inferior lobe and in the "giant" cells of cerebellum have been observed. The fibres and interstitial tissue are found to be negative. In olfactory bulb, the positive neurons are mainly scattered in the centre (Plate II–1) and only some are densely present near the periphery. The reaction in olfactory tract is similar to that of *Notopterus*. In axial lobe, the positive neurons are well scattered throughout (Plate II–1) and an aggregation of them is present where it joins the infundibulum. The arrangement of positive neurons in infundibulum (Plate II–2) and inferior lobe (Plate II–3) is similar to that found in *Notopterus*.

In tectum opticum, the neurons present a deep positive reaction and these neurons in lower region are interspersed with flask shaped unstained areas (Plate II–4), which represent the groups of fibre bundles extending between the two tecti optici. The region where the torus longitudinalis is not attached to the tectum opticum, the positive neurons are continuous throughout below the flask-shaped areas, otherwise they are interrupted by fibres extending between the tectum opticum and torus longitudinalis. In torus longitudinalis, the positive neurons are grouped to form three layers (Plate II–5), the lower thick layer is

PLATE I

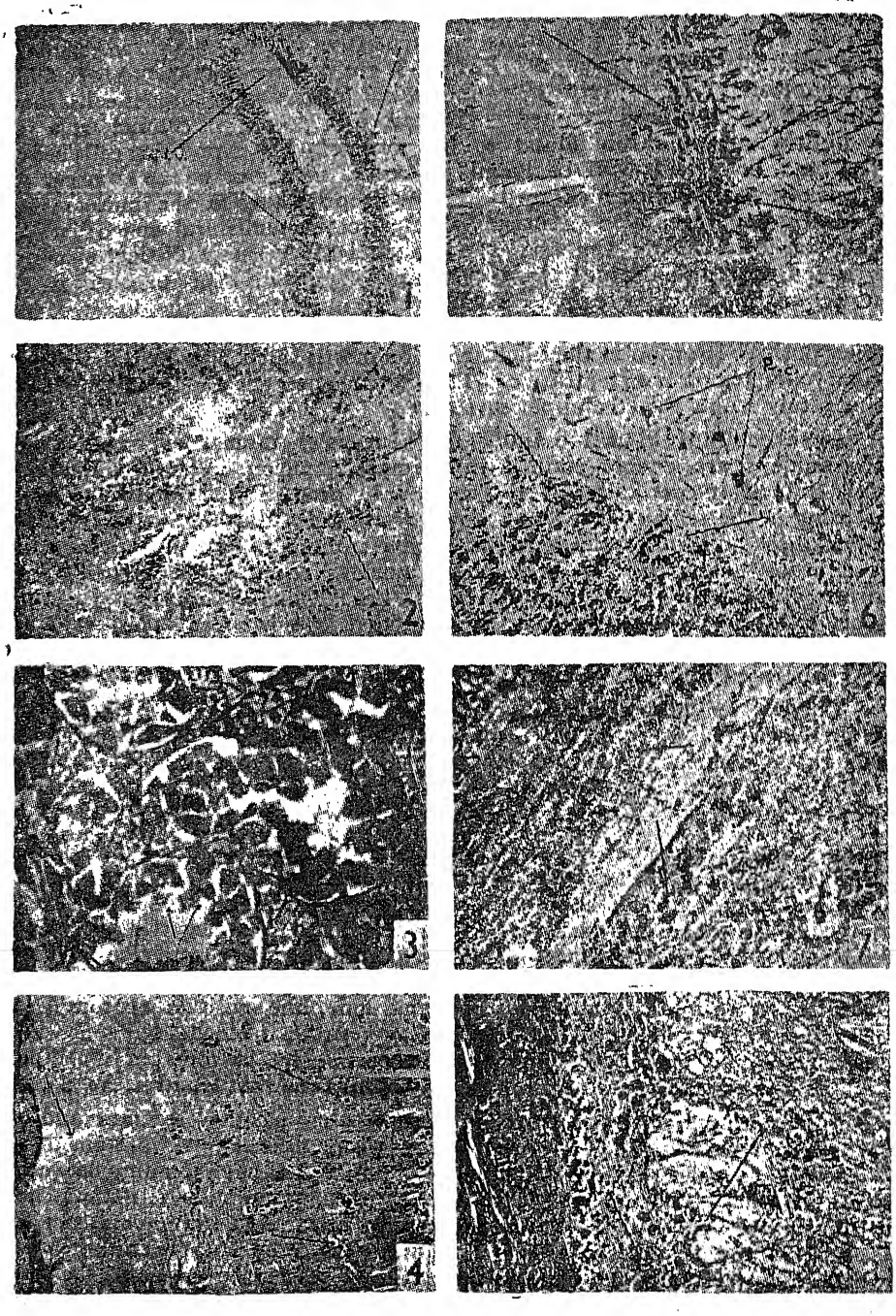
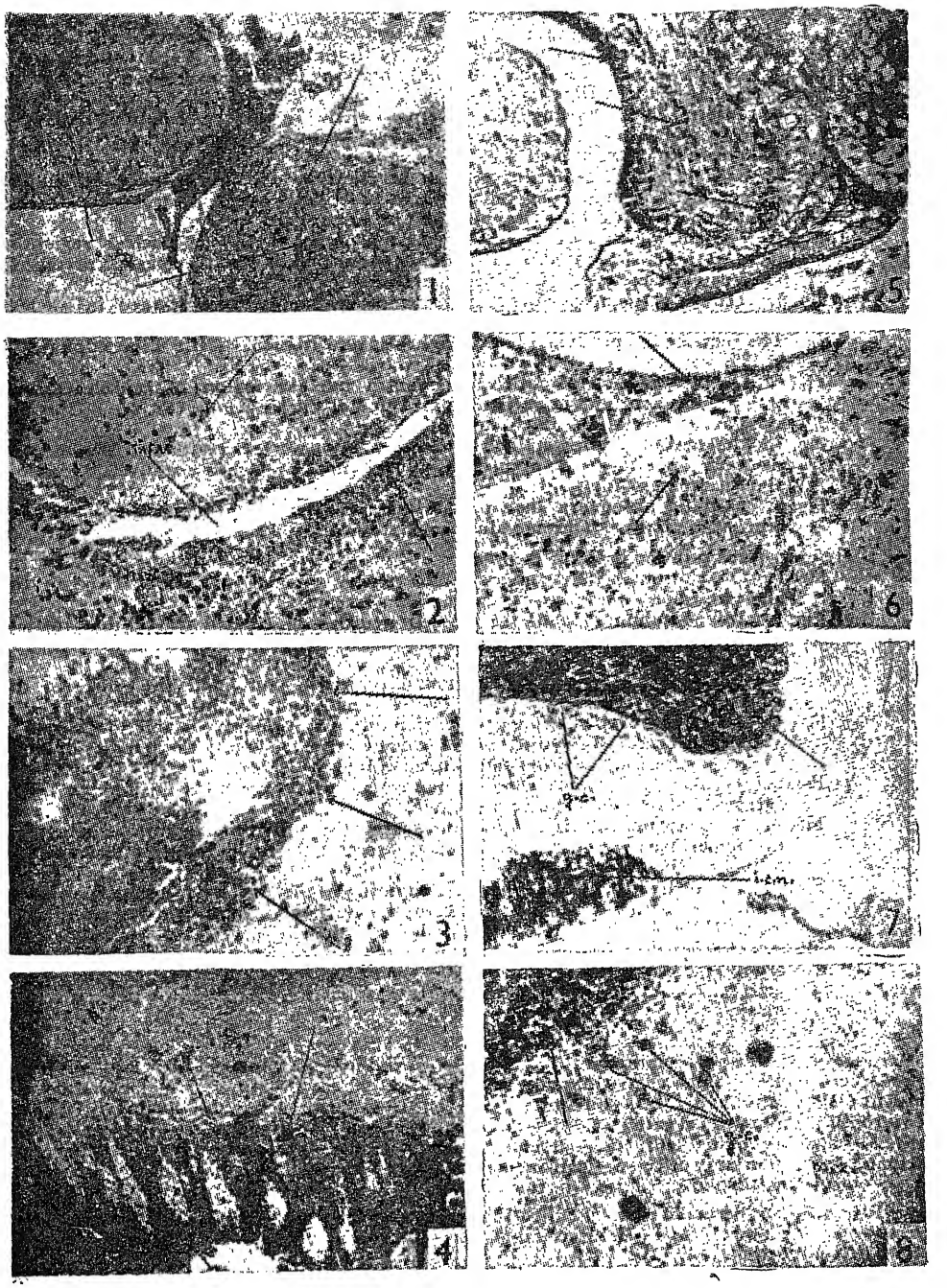


PLATE II



EXPLANATION OF FIGURES

PLATE I. Lipofuschin in the brain of *N. notopterus.*

Fig. 1. Infundibulum showing positive reaction in nuclear region of neurons (arrows) around the ventricle (inf. l. v.) of infundibulum. A few neurons (left) above the infundibular ventricle show only perikaryonal region stained. (Chrome-alum haematoxylin) × 130.

Fig. 2. Inferior lobe showing the staining mostly in the perikaryonal region of neurons, which are aggregated in groups (arrows) in central region of lobe. (Chrome-alum haematoxylin) × 130.

Fig. 3. Saccus vesculosus-showing positive reaction in nuclear region of cell body of coronet cell and supporting cell and light reaction in apical protrusion, hairs and globules of coronet cell. (Chrome alum haematoxylin) × 421.

Fig. 4. Tectum opticum-showing the positive reaction in the nuclear region of neurons (arrows) and also in the nuclear region of blood corpuscles present in blood capallaries (b. c.) (Chrome-alum haematoxylin) × 130.

Fig. 5. Tectum opticum showing aggregation of positive neurons stained in nuclear region on ventral side (arrows) on either side of unstained stratum album centrale. The ventricular ependymal layer (right) is also stained. (Nile blue sulphate) × 130.

Fig. 6. Cerebellum showing positive reaction in nuclear region of neuron (arrow) of granular zone and in perikaryonal region of Purkinje cells (Pr. c.) (Chrome-alum haematoxylin) × 130.

Fig. 7. Cerebellum showing stained neurons in their nuclear region of granular zone arranged on either side of medullary layer (m. l.) which is negative. (Chrome-alum haematoxylin) × 130.

Fig. 8. Medulla oblongata showing positive staining in nuclear region of most of neurons (arrows). (Chrome-alum haematoxylin) × 130.

PLATE II. Lipofuschin in the brain of *P. ticto.*

Fig. 1. Olfactory bulb (left) and axial lobe (right), showing positive reaction in the nuclear region of neurons. (Chrome-alum haematoxylin) × 130.

Fig. 2. Infundibulum, showing the stained neurons aggregated around the ventricle (inf. v.) and scattered in the remaining area. (Chrome-alum haematoxylin) × 130.

Fig. 3. Inferior lobe showing aggregation of positive neurons in the centre of the lobe and around the ventricle. (Chrome-alum haematoxylin) × 130.

Fig. 4. Tectum opticum showing aggregation of positive neurons in the lower region with unstained flask shaped areas in between representing the bundles of inter-tectal commissure. (Chrome-alum haematoxylin) × 225.

Fig. 5. Torus longitudinalis showing positive neurons aggregated in three layers (arrows). (Chrome-alum haematoxylin) × 130.

Fig. 6. Torus semicircularis, showing the aggregation of positive neurons in a layer on the upper free margin besides being scattered throughout. (Chrome-alum haematoxylin) × 130.

Fig. 7. Cerebellum showing the positive staining in the nuclear region of neurons of granular zone (arrows) and interaccerebellar nucleus (i. c. n.) and in "giant cells" (g. c.) (Nile blue sulphate) × 130.

Fig. 8. Cerebellum showing the staining in the nuclear region of the neurons in granular zone (arrows) and in the nucleolus and perikaryonal region of giant cells (g. c.). The neurons of molecular zone (m. z.) are stained in nuclear region mostly. (Nile blue sulphate) × 421.

ABBREVIATIONS USED

a.—axon of fibre ; *ap.*—apical protrusion ; *Ax. l.*—axial lobe; *C.*—coronet cell ; *cb.*—cell body; *cerbl.*—cerebellum : *Epl.*—ventricular ependymal layer ; *F. and f.*—fibres ; *g.*—globules ; *g.c.*—"giant cell" ; *h.*—hairs : *Inf.*—infundibulum ; *Inf. l.*—inferior lobe ; *Inst.*—interstitial tissue (neuropil) ; *m.*—myelin sheath ; *M. obl.*—medulla oblongata ; *N.*—neuron : *n.*—nuclear region ; *Olf. b.*—olfactory bulb ; *Olf. tr.*—olfactory tract ; *op. n.*—optic nerve ; *p.*—perikaryonal region ; *Pr. c.*—Purkinje cell ; *S.*—supporting cell ; *sh.*—sheath ; *S. V.*—saccus vasculosus ; *T. l.*—torus longitudinalis ; *T. op.*—tectum opticum ; *T. s.* torus semicircularis.

10% *F.*—10% Formalin ; 10% *N.F.*—10% neutral formalin ; *Rosman*—Rossman's fluid ; *Bouin*—Bouin's fluid ; *Helly*—Helly's fluid ; *Carnoy*—Carnoy's fluid ; *For. cal.*—formol-calcium ; *Kahle.*—Kahle's fluid.

TABLE I

Showing the variation in the reaction of lipofuschin by chrome-alum haematoxylin method due to the use of different fixatives in N. notopterus

Region of brain		10% F	10% NF	Rosman	Bouin	Helly	Carnoy	For. cal.	Kahle
Olfb.	N–n/p	–/+++	–/++	–/+	–/+++	–/++	–/+++	–/++	–/+++
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Olf. tr.	F–m/a	–	–	–	–	–	–	–	–
Ax. l	N–n/p	–/+++	–/++	–/+	–/+++	–/++	–/+++	–/++	–/+++
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Inf. & Inf. l.	N–n/p	++/–	++/–	+/–	+++/–	+/–	+++/–	++/–	+++/–
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
S.V.	C N–n/p	++/–	++/–	+/–	++/–	+/–	++/–	+/–	+/–
	ap/h/g	+/–/–	+/–/–	+/–/–	+/–/–	+/–/–	+/–/–	+/–/–	+/–/–
	S	+++	++	+	+++	++	+++	++	++
T. op.	N–n/p	++/–	+/–	++/–	+++/–	++/–	+++/–	+/–	+++/–
	F–m/a	–	–	–	–	–	–	–	–
	Epl	–	–	–	–	–	–	–	–
	Inst.	+	–	–	+	–	+	–	+
T.l. & T. S.	N–n/p	++/–	+/–	+/–	++/–	++/–	++/–	++/–	++/–
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Cerbl.	N–n/p	++/–	++/–	+/–	+++/–	++/–	+++/–	++/–	+++/–
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Pr. c.	–n/p	–/+++	–/++	–/+	–/+++	–/++	–/+++	–/++	–/+++
M.obl–	N–n/p	+/–	+/–	+/–	+/–	+–	+/–	+/–	++/–
	F–m/s	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Op.n.–	sh/f	–	–	–	–	–	–	–	–

+++ = intense reaction; ++ = moderate reaction; + = weak reaction; – = negative reaction.

TABLE II

Showing the variation in the reaction of lipofuschin by chrome-alum haematoxylin method due to the use of different fixative in P. ticto

Region of brain		10% F	10% NF	Rosman	Bouin	Helly	Carnoy	For. cal.	Kahle
Olf. b.	N-n/p	++/–	+/–	+++/–	++/–	+/–	+/–	+/–	+/–
	F-m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Olf. tr.	F-m/a	–	–	–	–	–	–	–	–
Ax. l.	N-n/p	++/–	++/–	+++/–	++/–	+++/–	++/–	++/–	+/–
	F-m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Inf. & Inf. l.	N-n/p	++/–	++/–	++/–	++/–	+++/–	++/–	+/–	++/-
	F-m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
T. op.	N-n/p	++/–	++/–	+++/–	++/–	++/–	+++/–	+++/–	++/-
	F-m/a	–	–	–	–	–	–	–	–
	Epl.	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
T. l. & T. S.	N-n/p	+++/–	+++/–	+++/–	++/–	+++/–	++/–	++/–	++/-
	F-m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Cerbl.	N-n/p	++/–	+++/–	+++/–	++/–	+++/–	+++/–	+++/–	++/-
	F-m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
g. c.	-n/p	++/–	++/–	++/–	++/–	+++/–	++/–	++/–	++/-
M.obl.–	N-n/p	++/–	++/–	++/–	++/–	++/–	++/–	++/–	++/-
	F-m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Op.n.–	sh/f	–	–	–	–	–	–	–	–

+++ = intense reaction; ++ = moderate reaction; + = weak reaction; – = negative reaction.

TABLE III

Showing the variation in the reaction of lipofuschin by nile blue sulphate method due to the use of different fixatives in N. notopterus

Region of brain		10% F	10% NF	Rosman	Bouin	Helly	Carnoy	For. cal.	Kahle
Olf.b.	N–n/p	–/+	–/+	–/+	–/+	–/+	–/+	–/+	–/+
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Olf. tr.	F–m/a	–	–	–	–	–	–	–	–
Ax. 1.	N–n/p	–/++	–/+	–/+	–/+	–/+	–/+	–/++	–/++
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Inf. & Inf. 1.	N–n/p	++/–	+/–	+/–	+/–	+/–	+/–	++/–	++/–
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
S.V. C	N–n/p	++/–	+/–	+/–	+/–	+/–	+/–	++/–	+/–
	ap/h/g	+/–/–	+/–/–	–	–	–	+/–/–	+/–/–	+/–/–
S		++	+	+	+	+	+	+	+
T. op.	N–n/p	+/–	+/–	+/–	+/–	+/–	+/–	+/–	+/–
	F–m/a	–	–	–	–	–	–	–	–
	Epl.	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
T. 1. & T. S.	N–n/p	+/–	+/–	+/–	+/–	+/–	+/–	++/–	++/–
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Cerbl.	N–n/p	+/–	+/–	+/–	+/–	+/–	+/–	++/–	++/–
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Pr. c.	–n/p	–/++	–/+	–/++	–/+	–/++	–/+	–/++	–/++
M.obl.	N–n/p	+/–	+/–	+/–	+/–	+/–	+/–	+/–	+/–
	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Op.n.	sh/f	–	–	–	–	–	–	–	–

+++ = intense reaction ;++ = moderate reaction ; + = weak reaction ; – = negative reaction.

TABLE IV

Showing the variation in the reaction of lipofuschin by nile blue sulphate method due to the use of different fixatives in P. ticto

Region of brain		10% F	10% NF	Rosman	Bouin	Helly	Carnoy	For. cal.	Kahle
	N–n/p	+/–	+/–	++/–	++/–	+/–	+/–	+/–	+/–
Olf. b.	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Olf. tr.	F–m/a	–	–	–	–	–	–	–	–
	N–n/p	++/–	++/–	++/–	++/–	++/	++/–	+/–	+/–
Ax. l.	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
	N–n/p	+/–	+/–	++/–	+/–	++/–	+/–	+/–	+/–
Inf. & Inf. l.	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
	N–n/p	+/–	+/–	++/–	+/–	++/–	++/–	++/–	++/–
T. op.	F–m/a	–	–	–	–	–	–	–	–
	Epl.	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
	N–n/p	++/–	++/–	++/–	++/–	+/–	+/–	++/–	+/–
T. l. & T. S.	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
	N–n/p	++/–	++/–	++/–	++/–	++/–	+/–	+/–	+/–
Cerbl.	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
g. c.–n/p		+/–	+/–	++/–	++/–	++/–	+/–	++/–	+/–
	N–n/p	++/–	+/–	++/–	++/–	++/–	+/–	+/–	+/–
M.obl.–	F–m/a	–	–	–	–	–	–	–	–
	Inst.	–	–	–	–	–	–	–	–
Op.n.–	sh/f	–	–	–	–	–	–	–	–

+++ = intense reaction ; ++ = moderate reaction ; + = weak reaction ; – = negative reaction.

confined to free lower margin and the two upper thin layers run dorsal and parallel to the thick layer. In torus semicircularis, the positive neurons form a thin layer just beneath the upper surface (Plate II–6). In cerebellum (Plate II–7), the condition of the medullary layer, intracerebellar nucleus and cerebellar cortex is like that of *Notopterus*. Only in the case of 'giant cells' occupying the place of Purkinje cells, the positive reaction has been found confined to the nuclear region (Plate II–8) unlike that of *Notopterus*. In medulla, large number of positive neurons are aggregated to form a thin layer below the free margin of the facial and vagal lobes.

The optic nerve fibres react like other fibres, while its sheath gives a faint colouration only. The blood vessels show deep positive reaction in the nuclei of blood corpuscles (Plate II–1) while the walls are weakly stained.

Nile Blue Sulphate

The overall staining reaction of this technique is similar to the chrome-alum haematoxylin, except that the staining of neurons is not that much pronounced. The positivity of the perikaryonal and nuclear regions in various parts of brain in the two fishes remains the same as in chrome-alum haematoxylin technique. In *Notopterus*, the staining, however, is deep in the perikaryonal region of neurons, which are confined to the peripheral region instead of being distributed throughout. The staining in the connective tissue sheath of optic nerve is distinctly negative. In saccus vasculosus, the apical protrusion of coronet cells are either poorly stained or unstained. Certain large cells above the Purkinje cells in the molecular layer of cerebellum show their nuclei deeply stained (Plate 1–6). In Purkinje cells the processes show light staining as compared to chrome-alum haematoxylin technique. In *Puntius*, the neurons are rarely deeply stained, while the blood capallaries and blood corpuscles show a reaction similar to that of chrome-alum haematoxylin.

Discussion

The results are being discussed with the available literature on neurohistochemistry in general. The presence of lipofuschin has been reported in human medulla by Nasser, Issidorides and Shanklin (1960) and in the brain cells of *Psittacula* and *Acridotheres* by Singh (1963). In the present study, lipofuschin granules are noted in the nuclear or perikaryonal region of brain cells in *Notopterus*, while only in the nuclear region of these cells in *Puntius*.

Shanklin, Issidorides and Nasser (1957) consider the formation of lipofuschin granules by the secretory activity of neurons other than neurosecretory cells of hypothalamus and the granules have been found by them in various stages of development. The formation of granules is reported due to the synthetic cellular activity by Sulkin and Srivany (1960) and by catabolic activity of neuronal cytoplasm by Dixon (1955). Their appearance by the dieting factor like lack of vitamin E has been put forward by Einarson (1953), and they have been considered as waste product of neurons by Dixon (1955). Singh (1963) in his studies on *Psittacula* and *Acridotheres* has supported the view of Shanklin, Issidorides and Nasser (1957) in the formation of granules by secretory activity, owing to their presence in various stages of development. This view has been supported by the present study on the two fishes.

The extracellular lipofuschin granules in the human brain has been reported by Shanklin, Issidorides and Nasser (1957) and in the interstitial tissue of the brain, Purkinje cells zone, granular layer, striated areas and blood vessels in *Psittacula* and *Acridotheres* by Singh (1963). In the present investigation, these extracellular granules have been observed in the interstitial tissue and between the optic nerve fibres in *Notopterus* and *Puntius*. The extracellular occurrence of lipofuschin is suggested due to their secretion in the neurons, getting discharged and reaching the blood vessels by Shanklin, Issidorides and Nasser (1957), which is supported by Singh (1963) and present observations. The occurrence of granules near and inside the blood vessels and the presence of enzymes in neuronal lipofuschin led Issidorides and Shanklin (1961) to observe that the granules may be carrier of some neuronal secretion. A similar view has been put forward by Gedigk and Bronte (1956) owing to the acid phosphatases and non-specific esterases having the same distribution as lipofuschin granules. The view of Issidorides and Shanklin (1961) is corroborated by the migratory nature of the granules, which occur mostly in the nuclear region in *Puntius* and moving from nuclear to the perikaryonal region in *Notopterus*.

Summary

In *Notoperus*, most of the neurons react positively either in the perikaryonal or in the nuclear region. The Purkinje cells are positive in perikaryonal region and some large neurons above them are positive in nuclear region. Besides supporting cells, the coronet cells of saccus vasculosus show intense reaction in the nuclear region of cell body, weak in apical protrusion and rarely in hair and globules. In *Puntius*, the neurons are positive mostly in the nuclear region. The extracellular lipofuschin granules occur in the interstitial tissue and between optic nerve fibres.

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Rhizosphere fungi of two cultivated Legumes*

By

(KM.) S. GUJARATI

Department of Botany, Banaras Hindu University, Varanasi–5

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Introducton

Work on soil fungi in this laboratory has been carried out by a few workers but they confined themselves solely to that part of soil which was away from the roots, though strictly speaking, not free from the influence exerted by them. In other laboratories also of the country no one has ever tried to study in detail the rhizosphere microflora of *Lens esculenta* Moench-Meth. and *Cicer arietinum* Linn. which are two most important genera of Leguminosae grown here, except Mehrotra *et al* (1963) who reported *Aspergilli* and *Penicillia* occurring in the rhizosphere of *Cicer arietinum*. It was, therefore, considered worth while to study the rhizosphere microflora of these two plants.

Materials and Methods

Four plots each of *Lens esculenta* and *Cicer arietiuum* were selected for rhizosphere fungal study. Plots I and II in both the cases were cultivated fields while III and IV were adjacent experimental plots (10′ × 10′ in size) prepared in uncultivated field. For the study of rhizosphere microfungi, the plants were taken out from the soil with a sterilized spatula and the extra soil particles attached to them were removed by giving a gentle shake. The above roots containing closely adhering soil were gently shaken in the sterile water.

The conventional dilution plate method was adopted for the inoculation of the rhizosphere soil samples. The agar medium of following composition, found to be most satisfactory for fungal growth after trying various culture media, has been used.

Dextrose, 10 g. ; peptone, 5 g. ; KH_2PO_4, 1 g. ; $MgSO_4 \cdot 7H_2O$, 0·5 g. ; agar, 20 g. ; distilled water, 1 litre ; rose bengal 1 : 30,000.

The Petri-plates were examined after five days of incubation at 25°C (the optimum temperature for growth of the fungi) and species identified were recorded.

The fungal species isolated are tabulated in Tbale I.

Results

(*A*) Distribution of fungi in rhizosphere of *Lens esculenta*. Forty-one, forty-four, and thirty-eight species were isolated from the rhizosphere of plots I, II, III and IV respectively. Plot I harboured 7, 2 and 32 species of Phycomycetes, Ascomycetes and Deuteromycetes respectively. Except *Mucor luteus* and *Rhizopus nigricans* which were among the dominant forms in the seedling stage of the plants, other forms were occasionally isolated. The two ascomycetous forms, viz., *Thielavia terricola* and *Aspergillus nidulans* were of very low frequency and of rare

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occurrence. The maximum number of fungi belonged to Deuteromycetes and *Aspergillus niger, A. terreus, Penicillium humicola* and *Fusarium nivale* were the dominant ones. The dematiaceous forms were present with higher frequency at the later stage of the plant growth when the roots decayed (Table I).

Plot II favoured the growth of 7, 4 and 33 species of Phycomycetes, Ascomycetes and Deuteromycetes respectively. *Rhizopus nigricans* was the dominant form in the early stage and other forms appeared occasionally. Four Ascomycets, viz., *Chaetomium globosum, Gymnoascus* sp. *Neocosmospora vasinfecta* and *Aspergillus nidulans* were occasionally isolated and that too with low frequency. *Aspergillus flavus, A. terreus, A. niger, Curvularia lunata, Cladosporium herbarum, Alternaria tenuis* and *Fusarium tricinctum* were the dominants.

Six, three and twenty-one species of Phycomycetes, Ascomycetes and Deuteromycetes were obtained from plot III. *Mucor luteus* and *Rhizopus nigricans* were the dominant species. *Thielavia terricola, Chaetomium globosum* and *Penicillium brefeldianum* were the only Ascomycetous forms with rare distribution. Of the Deuteromycetes *Aspergillus niger, A. flavus, A. terreus, Penicillium humicola, P. purpurogenum, Curvularia lunata, Alternaria tenuis* and *Fusarium nivale* were dominant forms, other species of the group were represented with low frequency.

The maximum number of phycomycetous species obtained from plot IV was 8. *Mucor luteus, Rhizopus nigricans* and *Cunninghamella blakesleeana* were dominant. Two infrequent Ascomycetes were *Thielavia terricola* and *Aspergillus nidulans*. Of the 28 Deuteromycetes *Aspergillus niger A. terreus, Penicillium humicola, Curvularia lunata* and *Alternaria tenuis* were the dominant forms.

(*B*) Distribution of Micro-fungi in rhizosphere of *Cicer arietinum*.

Thirty-four species were isolated from plot I. Members of Ascomycetes were absent. Phycomycetes and Deuteromycetes were represented by 6 and 28 species respectively. Amongst phycomycetous forms *Mucor hiemalis* and *Rhizopus nigricans* were dominant, others were obtained infrequently. *A. terreus, A. flavus, Penicillium humicola, P. funiculosum, Gliocladium roseum, Curvularia lunata, Cladosporium herbarum* and *Alternaria humicola* were the dominant species of the Deuteromycetes (Table I).

Plot II harboured 9, 1 and 26 species of Phycomycetes, Ascomycetes and Deuteromycetes respectively. *Mucor hiemalis* and *Rhizopus nigricans* were dominant particularly in early stage of the plant growth and the rest were only of occasional occurrence. The Ascomycetes representative isolated was only *Aspergillus nidulans. Aspergillus niger, A. flavus, A. terreus, Trichoderma viride, Penicillium humicola, Gliocladium roseum, Cladosporium herbarum, Curvularia lunata, Alternaria tenuis* and *Fusarium nivale* were the dominant deuteromycetous forms.

Plot III possessed 47 species, of which 10, 3 and 34 were from Phycomycetes, Ascomycetes and Deuteromycetes respectively. *Mucor hiemalis* showed high frequency. Other species were of low frequency. All the ascomycetous forms were isolated with low frequency. The dominant forms amongst Deuteromycetes were *Trichoderma viride Aspergillus niger, A. terreus, A. flavus, Penicillium humicola, Curvularia lunata, Cladosporium herbarum, Alternaria humicola* and *Fusarium nivale*.

Plot IV harboured 43 species which consisted of 8 Phycomycetes, 2 Ascomycetes and 33 Deuteromycetes. *Mucor hiemalis, Rhizopus nigricans* and a phycomycetous sterile colony were the dominant phycomycetous forms, other species of this group were infrequently represented. The ascomycetous species obtained were only *Aspergillus nidulans* and *Penicillium brefeldianum. Trichoderma viride, Aspergillus niger, A. terreus, A. flavus, Penicillium humicola, Curvularia lunata* and *Fusarium nivale* were dominant forms of Deuteromycetes.

TABLE 1

Distribution of the fungi in rhizospheres of Lens esculenta *and* Cicer arietinum

Fungi/plots	Lens esculenta				Cicer arietinum			
	I	II	III	IV	I	II	III	IV
Mucer luteus Linn.	+	+	+	+	+	+	+	+
M. hiemalis Wehmer	+	−	+	+	+	+	+	+
M. plumbeus Bonorden	−	−	−	−	+	+	+	−
Gongronella butleri (Lendn.) Peyronel and Dalvesco	+	+	−	−	−	−	−	−
Rhizopus nigricans Ehrenberg	+	+	+	+	+	+	+	+
R. oryzae Went and Gerlings	+	+	+	−	−	−	−	−
Phycomycetous sterile colonies	+	+	+	+	−	+	+	+
Zygorhynchus heterogamus (Vuill.)	−	−	−	+	−	+	+	+
Choanephora cucurbitarum (Berkley and Ravenel) Thaxter	−	+	−	+	+	+	+	+
Cunninghamella blakesleeana Lendner	+	+	+	+	+	+	+	+
C. echinulata Thaxter	+	−	−	−	−	−	+	−
Syncephalastrum racemosum (Cohn) Schroeter	−	+	−	+	−	+	+	+
Gymnoascus sp.	−	+	−	−	−	−	−	−
Thielavia terricola (Gilman and Abbott) Emmons.	+	−	+	+	−	−	+	−
Chaetomium globosum Kunze	−	+	+	−	−	−	+	−
Neocosmospora vasinfecta E. F. Smith	−	+	−	−	−	−	−	−
Aspergillus nidulans (Eidam) Wint.	+	+	−	+	−	+	+	+
Penicillium brefeldianum Dodge	−	−	+	−	−	−	−	+
Phoma hibernica Grimes, O'Connor and Cummins		+	−	−	+	+	+	+
Chaetomella raphigera M. E. Swift	−	−	−	−	−	−	+	+
Trichoderma viride Pers. ex. Fr.	+	+	+	+	+	+	+	+
Aspergillus niger Van Tiegham	+	+	+	+	+	+	+	+
A. terrus Thom	+	+	+	+	+	+	+	+
A. flavus Link	+	+	+	+	+	+	+	+
A. candidus Link	+	+	+	+	+	+	+	+
A. sydowi (Bain. and Sar.) Thom and Church	+	+	+	+	+	+	+	+
A. sulphureus (Fres.) Thom and Church	−	+	−	−	+	−	+	−
A. fumigatus Fres	−	−	+	−	−	−	−	−
A. japonicus Saito	+	−	−	−	−	−	−	−
A. awamori Nekzawa	−	−	−	−	−	−	+	−

Fungi/plots	Lens esculenta				Cicer arietinum			
	I	II	III	IV	I	II	III	IV
Penicillium humicola Oud.	+	+	+	+	+	+	+	+
P. notatum Westling	+	+	+	+	+	−	+	+
P. funiculosum Thom	+	+	+	+	+	+	+	+
P. purpurogenum Stoll	+	+	+	+	+	−	+	+
P. rubrum Stoll	−	+	−	−	−	−	−	−
P. variabile Sopp.	−	+	−	−	−	−	+	+
P. restrictum Gilman and Abbott	+	−	−	−	−	−	−	−
Paccilomyces fusisporus Saks.	+	+	+	+	+	+	+	+
P. varioti Bainier	+	+	−	−	−	−	−	−
Fusidium sp.	−	+	−	−	−	−	+	−
Acremonium sp.	+	−	−	−	−	+	−	−
Cephalosporium coremioides Raillo	+	−	−	−	+	+	+	+
C. asperum Marchal	+	+	−	+	−	−	−	−
C. acremonium Corda	−	−	−	−	+	−	−	−
Sporotrichum chlorinum Link	−	−	−	−	−	−	+	−
Gliocladium fimbriatum Gliman and Abbott	−	−	−	+	−	−	−	−
G. roseum (Link) Thom	−	−	−	−	+	+	+	+
Monilia geophilla Oud.	−	+	−	−	−	−	−	−
Curvularia lunata (Walker) Boedijn	+	+	+	+	+	+	+	+
C. geniculata (Tracy and Earle) Boedijn	+	−	−	−	−	−	−	+
C. tuberculata Jain	−	−	−	−	−	+	−	−
Cladosporium herbarum (Persoon) Link.	+	+	+	+	+	+	+	+
Alternaria tenuis Nees	+	+	+	+	+	−	−	−
A. humicola Oud.	+	+	+	+	+	+	+	+
Hormodendron sp.	−	−	−	−	+	+	+	+
Papulospora sp.	+	+	−	+	+	−	+	+
Humicola fusco-atra Traaen	+	+	+	+	+	+	−	+
Helminthosporium anomalum Gilman and Abbott	+	+	+	+	+	+	+	+
H. flagelloideum Atkinson	+	−	−	−	−	−	−	−
H. nodulosum (Berkeley and curtis) Sacc.	−	−	−	−	−	−	−	+
Scolecobasidum terreum Abbott	−	−	−	−	−	−	+	+
S. constrictum Abbott.	−	−	−	−	−	+	−	−
Hormiscium sp.	−	−	−	+	−	+	−	+
Fumago sp.	−	−	−	−	+	+	−	−
Fusarium nivale (Fries) Cesati	+	+	+	+	+	+	+	+

Fungi/plots	Lens esculenta				Cicer arietinum			
	I	II	III	IV	I	II	III	IV
F. oxysporum Schlechtendahl	−	+	+	+	−	+	−	−
F. tricinctum (Cda.) emend	+	+	+	+	+	+	+	+
F. roseum (LK.) emend	+	−	−	+	+	+	+	+
F. chlamydosporum Wollenweber and Reinking	−	−	−	−	−	−	−	+
Myrothecium verrucaria (Albertini and Schwinitz) Ditmar	−	+	−	+	−	−	+	−
M. roridum Tode	+	+	−	+	−	−	+	+
Sclerotium rolfsii Sacc.	+	+	−	+	−	−	+	+
Sterile colonies	+	+	−	+	−	+	+	+

Discussion

The microfungal community is correlated with the species composition of the cover vegetation. A change in the condition of the surface vegetation greatly influence the soil microbes.

Bisby *et al* (1935), Webley *et al* (1952), Christensen (1960), Bhuvaneswari and Subba Rao (1957), Rao (1962) and Alexander (1961) have shown that different plant species often establish somewhat different subterranean flora. Timonin (1941) suggested the development of specific rhizosphere microflora. However, Parkinson *et al* (1963) and Rangaswamy and Vasanthraja (1962) could not find significant difference rhizosphere population of different plant species.

In the present work the total number of species isolated from the rhizosphere of *Lens esculenta* and *Cicer arietinum* were 58 and 60 respectively (Table 1). Most of the species, excepting a few, isolated were common to the rhizospheres of both the plants. This similarity may be attributed to the fact that both plants belong to same family with similar morphological habits.

However, a few forms, e.g. *Rhizopus oryzae, Neocosmospora vasinfecta, Gymnoascus* sp., *Aspergillus japonicus A. fumigatus, Gliocladium fimbriatum, Cephalosporium asperum, Monilia geophila* and *Helminthosporium flagelloidenum* were specific to the rhizosphere of *Lens esculenta* and *Mucor plumbeus, Chaetomella raphigera, Aspergillus awamori, Gliocladium roseum, Cephalosporium acremonium, Sporotrichum chlorinum, Scolecobasidium terreum, S. constrictum* and *Helminthosporium nodulosum* to the rhizosphere of *Cicer arietinum* (Table I).

The specificity of these fungi may be ascribed to the difference in the amino-acids contents of both the plants (Author's observation) and consequently of cover vegetation.

Summary

The rhizosphere fungal flora of two cultivated legumes, viz. *Lens esculenta* and *Cicer arietinum* have been described. Majority of the fungal species isolated from the rhizosphere of the two plants were of common occurrence. A few forms showed specificity which may be due to difference in the amino-acids contents of the two legumes.

Acknowledgments

The author wishes to express her greatfulness to Dr. R. Y. Roy, D.I.C., for his valuable guidance, to Professor R. Misra, F.N.I. for laboratory facilities and to the Council of Scientific and Industrial Research for the financial assistance.

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Effect of different hosts on the length of Larval period in gram cut worm *Agrotis flammatra* Schiff. (Noctuidae : Lepidoptera)

By

A. N. CHATTORAJ & D. R. YADAVA

Zoology Department, University of Allahabad

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Introduction

It is a well known fact that besides the climatic conditions the desired food is one of the most important factors that determines to a large extent the distribution and population build up of the insects. Srivastava (1959) has worked out the growth potential of *Laphygma exigua* Hb. in relations to winter host plants and he emphasized that this type of information is more needed in case of polyphagous insect-pests. Lefroy, 1908 ; Basu, 1944 ; Thobbi, 1961 ; Rattan Lal and Nayak, 1963 ; Pandey and Srivastava, 1967 have also worked on the growth of *Prodenia litura* F. and found that food plants play an important role in the growth of this insect. The present work was undertaken to know the effect of different hosts on the length of larval period in gram cut-worm *Agrotis flammatra*, because it is a polyphagous insect-pest of agricultural importance and is capable of laying large number of eggs, which helps in designing the experiment at the sametime on number of crops. It is known to feed on cereals, pulses, oilseeds and fibre crops, but the damage is more serious to Gram, Pea and Wheat in U. P. The damage to potato crop in India varies from 12% to 35% by gram cut-worm.

Material and Methods

The larvae (caterpillars) of gram cut-worm (*Agrotis flammatra*) were collected from the fields of tobacco plants in the months of January and February, 1967. They were reared in the laboratory and the moths emerged were fed on 50% honey and sugar solution. Eggs laid were separated daily. 15 newly hatched larvae of the same day's hatch were transferred into the 5 sets of petri dishes of 4″ diameter, containing the fresh, tender leaves of the food plants viz., Gram, Potato, Tobacco, Tomato and wheat respectively. They were provided daily with fresh food. As they grew older, they were transferred to the glass troughs of 6 × 4″ size, mouths of which were covered with cheases cloth. Fully grown larvae were transferred to troughs having 2″ of moist soil for pupation. They pupated in the soil. Larval period was observed on the food supplied. Moths emerged were again provided with the same food as described above. The whole experiment was replicated three times, and data were recorded.

Results and Discssion

TABLE I

Showing the range and mean larval period of gram cut-worm on different hosts

Name of the food plant	Replication	No. of larvae kept for observation	Range in the larval period in days	Mean of larval period
Gram	I	15	23–25	23·6 days
	II	15	22–24	
	III	15	23–25	

Potato	I	15	25–27	
	II	15	21–30	
	III	15	26–31	26 66 days
Tobacco	I	15	23–24	
	II	15	31–33	
	III	15	27–29	27·8 days
Tomato	I	15	30	
	II	15	27–28	
	III	15	30	29·16 days
Wheat	I	15	21–22	
	II	15	21	
	III	15	21	21·16 days

It is evident from the above data that the caterpillars completed their development in shortest period on the wheat and maximum time was taken on tomato. They can be arranged on the basis of the time taken to complete the larval life as Gram, Potato and Tobacco respectively.

It can also be concluded that there is practically very little difference when reared with the Potato and Tobacco crops, so far the length of larval period is concerned or they exerted similar effect. Further, the larval period was found shorter on Gram than Potato. The latter crop is superior to the Tobacco. On the whole, it is clear that the length of larval period is greatly influenced by the host plants.

Summary

Caterpillars of gram cut-worm were collected from the fields of Tobacco crop and were reared in the Laboratory. Moths emerged were provided with 50% Honey and Sugar solution. Eggs laid were separated daily. Effect of 5 host plants viz., Gram, Potato, Tobacco, Tomato and Wheat on the durations of larval period was studied. It was found the shortest larval period was on wheat and longest was on Tomato, followed by Gram, Potato and Tobacco respectively.

Acknowledgements

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The Vertebral Column, Girdles and Fins in *Cirrhina mrigala* (Ham.)*

By

P. K. SAXENA**

Department of Zoology, Meerut College, Meerut (India)

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Among the Cyprinoid fishes, though complete osteology of *Labeo rohita* and *Catla catla*, is available ; need for accounts of a few more commonly available forms is being urgently felt. The present paper follows the account of head skeleton.

Observations

Vertebral Column :

The *vertebral column* is formed of forty vertebrae and consists of the anterior trunk and posterior caudal regions. The trunk region includes about twenty-four vertebrae, which may be distinguished into an anterior part of complex vertebra together with the Weberian ossicles, a middle part of fifteen vertebrae and a posterior part of five vertebrae. The *complex vertebra* (I-1) is formed of anterior-most four vertebrae which are very much modified in relation to the Weberian apparatus. The first vertebra is very much reduced and has a short cylindrical centrum with a flat anterior and a concave posterior face. A pair of well defined processes project horizontally outwards, which are considered as ribs of this vertebra (Ramaswami, 1955), while the neural arch of this vertebra is said to form the claustrum and scaphium (Ramaswami, 1955). The centra of the second and third vertebrae are fused into the single large centrum, which is deeply concave on its either side. The anterior part of the centrum bears a pair of processes, which are stated to be the ribs of second vertebra (Ramaswami, 1955). The posterior part of the centrum, representing actually the centrum of third vertebra, carries on eithr side the tripus. The neural arches of the second and third vertebrae are also fused and the fused neural arch consists of two ventro-lateral and one dorsal pieces. The fused neural spines likewise form a large flattened keel-like structure articulating with supraoccipital in front and with the neural spine of fourth vertebra behind. The fourth vertebra has well developed amphicoelous centrum and its neural arch and neural spines are applied against the fused neural arches and neural spines of the second and third vertebrae in front and with the neural arch and neural spine of fifth vertebra behind. On each side of the centrum arise two stout processes, a strong lateral and an usual ventromesial, which are flattened at their distal ends. The ventromesial processes form a vertical wall in the middle line behind the basioccipital, along which is attached the anterior end of the air bladder. The lateral processes represent the ribs of fourth vertebra, while the ventral processes represent the parapophyses of fourth vertebra.

*Part of the M.Sc. thesis.

**Present Address* : Assistant Professor of Zoology, Punjab Agricultural University, Ludhiana (India).

A vertebra from the middle part may be taken as the *typical vertebra* (I-5 and 6) of trunk region. Its centrum is amphicoelous and the space between the centra of adjacent vertebrae is filled with the remains of notochordal tissue. The dorsal and ventral surfaces of the vertebra are provided with a well developed median dorsal depression and a less prominent median ventral depression. The sides of centrum also have dorsolateral and ventrolateral depressions. From the anterolateral border of the median dorsal depression arises a pair of processes directed obliquely backwards, which unite to form the neural arch. The neural arch is produced distally into a long backwardly directed neural spine. The neural arch is thick and broad at the base and it gives in front a pair of small and blunt anterior zygapophyses, which are directed upwards and forwards. From the posterior side of neural arch also arises a pair of posterior zygapophyses directed upwards and backwards. The anterior zygapophyses of a vertebra appose the posterior zygapophyses of preceding vertebra and enclose a pair of foramina for the spinal nerves between them. From the ventrolateral surface of the centrum are given off a pair of parapophyses, one on either side and each parapophysis runs backwards supporting a rib at its distal end. The vertebrae of posterior trunk part are similar to the typical vertebra of trunk, except for the better developed parapophyses, which increase gradually in length towards posterior side. The last two vertebrae of trunk region (I-4) deviate from the typical structure by the absence of ribs and the presence of transverse bridge-like connection between their parapophyses.

The caudal region is composed of sixteen vertebrae. A *typical caudal vertebra* (I-2 and 3) bears a short and deeply amphicoelous centrum with the median dorsal and median ventral and paired dorsolateral and ventrolateral depressions. The neural arch and the anterior and posterior zygapophyses are of the usual type. The neural spine is more elongated and much more backwardly directed than those of the trunk vertebrae. From the antero-lateral borders of the median ventral depression arises a pair of processes running obliquely downwards and meet in the mid-ventral line to form the heamal arch. The heamal arch bears a pair of spine-like antero-ventral processes at its anterior border and are directed downwards and forwards. The posterior ventral processes are also present on the posterior side of haemal arch. The anterior ventral processes of a vertebra appose the posterior ventral processes of the preceding vertebra. Owing to the presence of pelvic girdle below, the first two caudal vertebrae are modified as their haemal spines are poorly developed and directed backwards. The last three caudal vertebrae, which support the caudal fin are also little different as in the penultimate caudal vertebra and one preceding it, the neural spines and haemal spines get flattened to serve as epiurals and hypourals respectively, while the last caudal vertebra is produced behind into an upturned rod-like urostyle bearing a groove beneath providing attachment to the first three hypourals. The neural spine of last caudal vertebra is free and a free radial lies above the urostyle.

The ribs are represented as fifteen pair of segmentally arranged elongated bony rods applied to the distal ends of parapophyses of all the vertebrae of trunk region, except the complex vertebra and the last two trunk vertebrae. Each rib is directed downwards between the muscle segments. The proximal end is expanded to articulate with the parapophysis of its trunk vertebra, while the distal end is pointed and ends freely in the musculature. The anterior pairs of ribs are comparatively stout and better developed than the posterior ones. In addition to the ribs, there are also present fine rib-like intermuscular bones. These are slender Y-shaped curved bones, with the two limbs of 'Y' directed proximally and the shank distally. They arise from the neural arch of the vertebrae of the

trunk and caudal regions and lie in the connective tissue septa between the myomeres with their distal ends being unifid, bifid or multifid.

Girdles :

The *pectoral girdle* (III–1) lies behind the branchial arches and comprised of two identical halves. Each half is formed of the primary endoskeletal part and the secondary dermal part. The primary part is reduced and lies closely approximated to the lower side of the secondary part. It is formed of the scapula, coracoid and mesocoracoid. The scapula is more or less a triangular bone, which lies below the cleithrum. Its outer end is closely applied to the inner surface of the cleithrum, while its front end is connected with the ridge on horizontal limb of the cleithrum and its inner end lies attached with the mesocoracoid. Along the hind face of scapula is applied the first fin ray and third and fourth radials. Together with the coracoid it gives a glenoid articular facet for the three radials. The bone is perforated by a scapular foramen. The coracoid is a prominent elongated bone below the horizontal limb of cleithrum. Its inner broad end articulates with the scapula, mesocoracoid and ridge on the horizontal limb of cleithrum. Its outer end meets in a symphysis with the one of other side, fusing with the horizontal limb of cleithrum. Behind the inner end of coracoid, it supports the first and second radials. The mesocoracoid is an inverted Y-shaped bone, which is applied closely to the inner surface of the cleithrum. The shank of the 'Y' is attached to the cleithrum. The outer limb of 'Y' running along the cleithrum is applied to scapula. The inner limb is attached to the coracoid and scapula. The mesocoracoid and scapula surround an oval recess, which lies over the scapular foramen.

The secondary part is well developed and consists of the cleithrum, supracleithrum, postcleithrum and posttemporal. The cleithrum is a large crescentric bone and comprises of a vertical part and a horizontal part. The vertical part is triangular and articulates above with the supracleithrum. The horizontal part is produced into a broad truncated end internally, which is connected with the fellow of the other side. On its lower side is a prominent ridge, which articulates with the coracoid. The supracleithrum is a dagger shaped bone, being overlapped by the posterior part of opercle. A small conical posttemporal bone articulates to the dorsal end of supracleithrum. The posttemporal extends upwards and is attached to the process of the epiotic below the supratemporal.

The *pelvic girdle* (III–2) is formed of a pair of pelvic bones. Each is a flattened irregularly triagular plate, which is divided into an anterior part and a posterior part. The anterior part is broad and elongated and bears a prominent groove. It is bifurcated in front into two processes, an inner and an outer. The inner process of the two pelvic bones meet in the middle line. The posterior process is rod-like and lies along the inner border of pelvic fin continued behind into a slender elongated piece of cartilage. The two posterior processes also meet partly in the middle line.

Fins :

The *pectoral fin* (III–1) consists of fifteen fin-rays supported on four radials. The fin-rays are segmented and gradually decrease in size and length posteriorly. The first fin-ray is the longest and unbranched, while the rest are branched. The cartilage between the fin-rays and the girdle is ossified by four radials lying one behind the other. The first fin-ray articulates with the scapula directly and the rest through their radials. Of these radials the first supports four fin-rays, the

second and third support two fin-rays each. The remaining seven are supported by fourth radial. The inter-radials are absent in the fish.

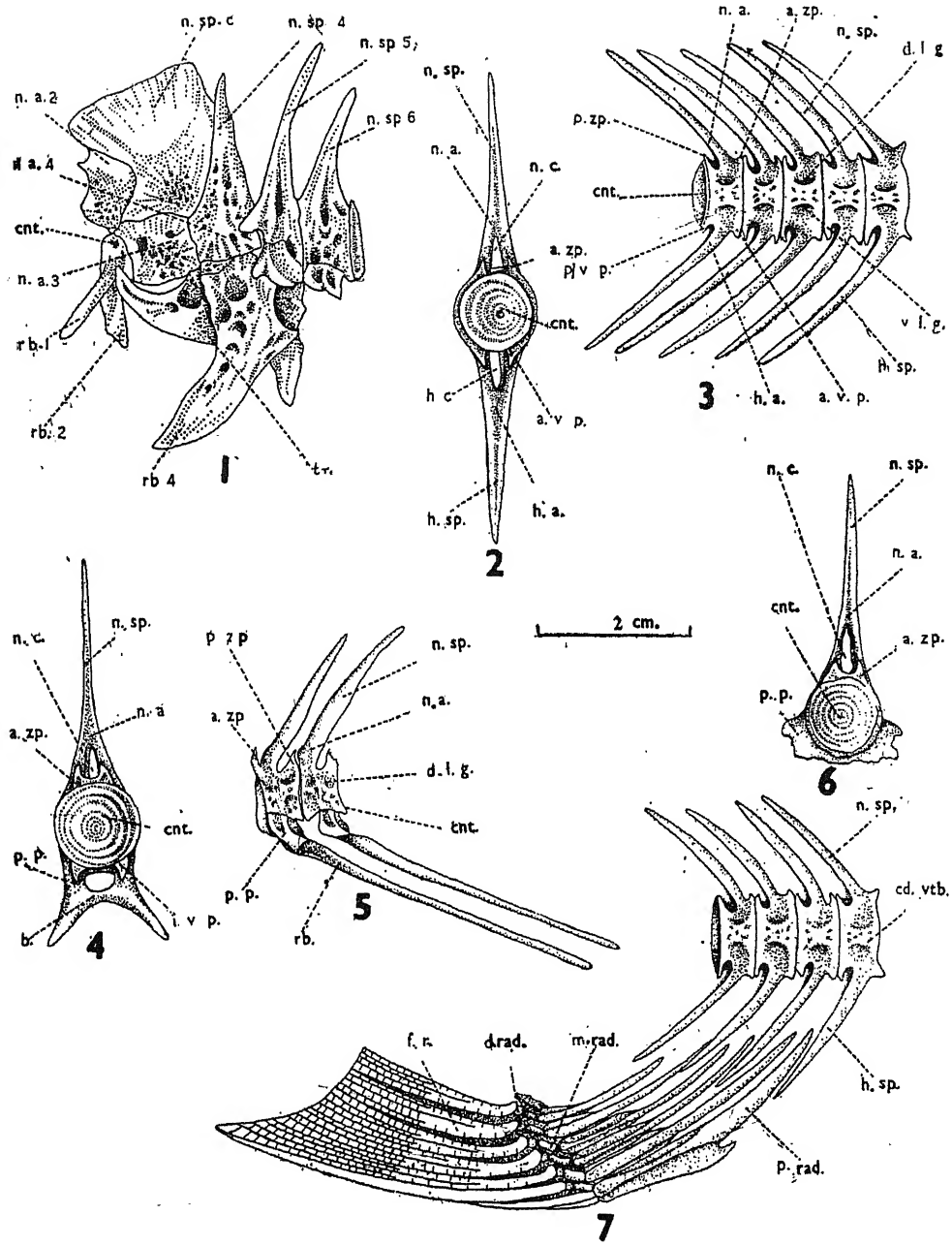
The *pelvic fin* (III-2) lies along the posterior margin of the pelvic bone, supported by three radials. It comprises of nine segmented fin-rays and an additional supernumerary. The fin-rays are branched except the first, which is unbranched. The supernumerary is in the form of a curved small rod which is attached to the first fin-ray directed away from the pelvic bone. As the radials are overlapped by the bases of fin-rays, their relation with the fin-rays can not be made out.

The *dorsal fin* (II-1) is supported by fifteen to sixteen fin-rays placed on fourteen to fifteen radials. Each radial consists of a large dagger-shaped proximal piece, a short mesial and a greatly reduced rounded distal piece. The mesial and distal segments of the first three radials can not be distinguished. The proximal piece bears four longitudinal ridges, an anterior, two anterolateral and a posterior. Its distal end is thick and broad and provided with a median and two lateral facets in front and a median facet behind. The anterior median facet articulates with the distal piece of preceding radial. The two anterolateral facets of proximal piece are occupied by the proximal ends of the paired lepidotrichia forming single ray and the posterior median facet is occupied by the mesial piece of the same radial, which lies obliquely between the proximal piece of same radial and the fin-ray of the succeeding radial.

The first radial is stout and is formed by the fusion of the two radials. It has a deep groove along its either side. There is a radial in each interspace from the tenth to twenty-first vertebrae, besides an additional radial in each of the interspace between the twelveth and thirteenth, fifteenth and sixteenth and seventeenth and eighteenth. The interspace between the eleventh and twelveth vertebra is without a radial, the last radial is ill developed and lies opposite the twenty second vertebra. There are fifteen to sixteen segmented fin-rays of which the first three are unbranched, small and not extending to the full length of the fin and the rest are branched. The first three unbranched fin-rays are carried by the first compound radial, while the rest of fin-rays are carried by the remaining twelve radials, *i.e.*, one in relation with each radial.

The *anal fin* (I-7) lies behind the anus and is formed of eight segmented fin-rays supported on six radials. The first three fin-rays are unbranched while the remaining are branched. Of the six radials, the first five are well developed and the sixth is small. Each radial comprises of usual three segments, the proximal, mesial and distal. The proximal radial is large and spine-like, with its proximal end present in between the haemal spine of two adjacent caudal vertebrae and its distal end joining the mesial segment. The mesial and distal pieces are similar to those of the dorsal fin. The radials are supported on the caudal vertebrae from fourth to seventh. There are two radials in each of interspaces between haemal spines of the fourth and fifth, fifth and sixth and sixth and seventh vertebrae. The first three fin-rays are unbranched, while the remaining are branched. The rays decrease in size from before backwards.

The *caudal fin* (II-2) is a large vertically expanded structure, being forked into the dorsal and ventral lobes. The dorsal lobe of the fin is formed of sixteen segmented fin-rays, of which ten rays extend the entire length of the fin lobe and the remaining six are confined to the base. Among the complete rays the first is unbranched and the longest, while rest are branched. The ventral lobe is formed of fourteen segmented fin-rays, nine of which extend the entire length of the fin lobe and the rest lie at the base. Of the complete rays of ventral lobe, the lower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tr.
1
n. sp.
n. a.
n. c.
a. zp.
p. v p.
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h. c.
a. v p.
h. sp.
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2
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3
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n. a.
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p. p.
6
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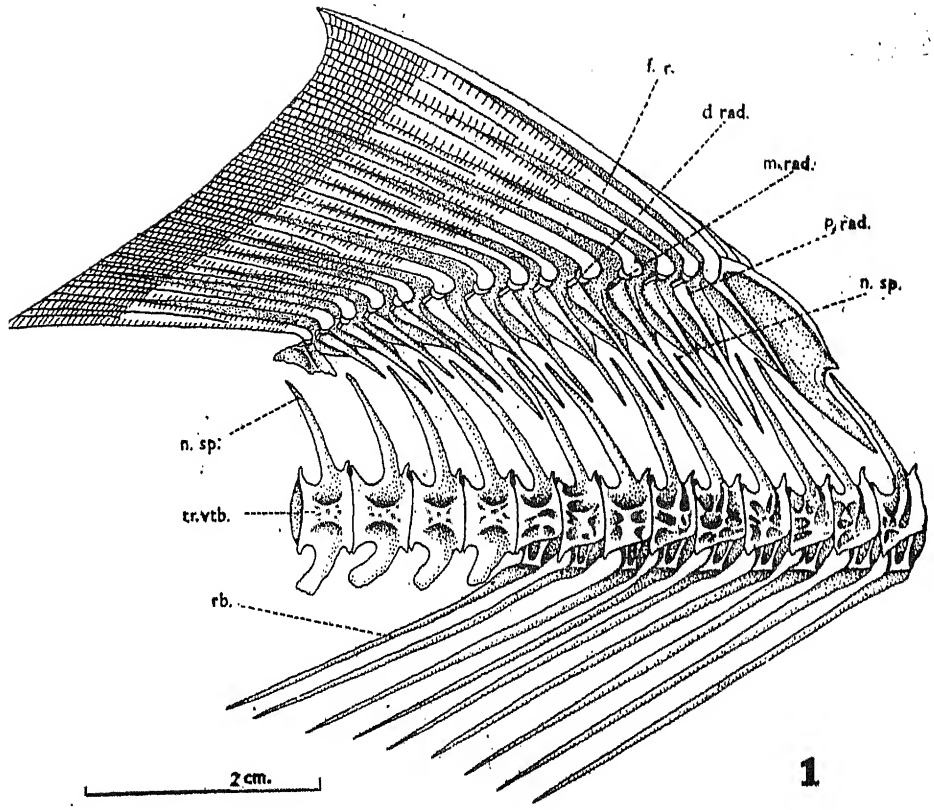
7

PLATE I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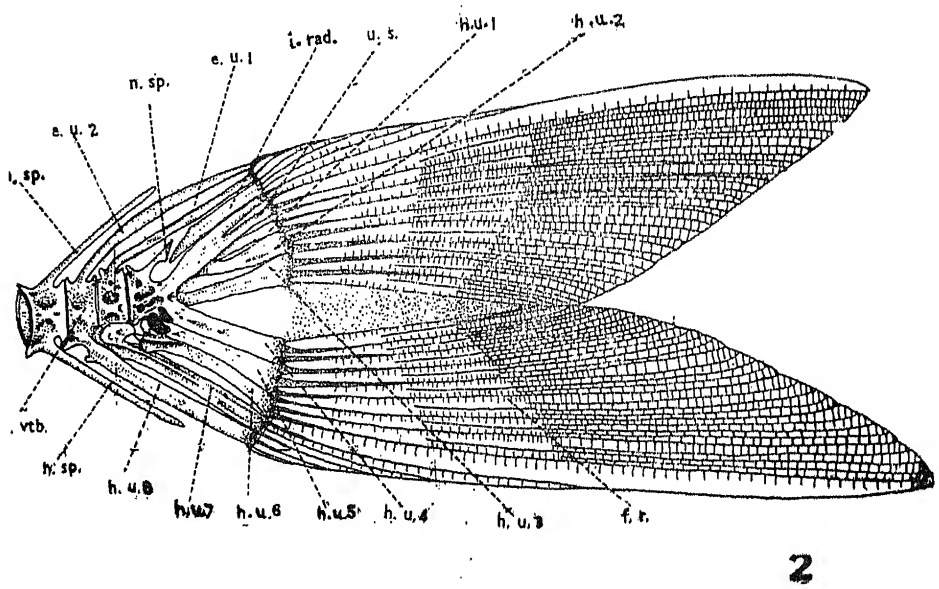
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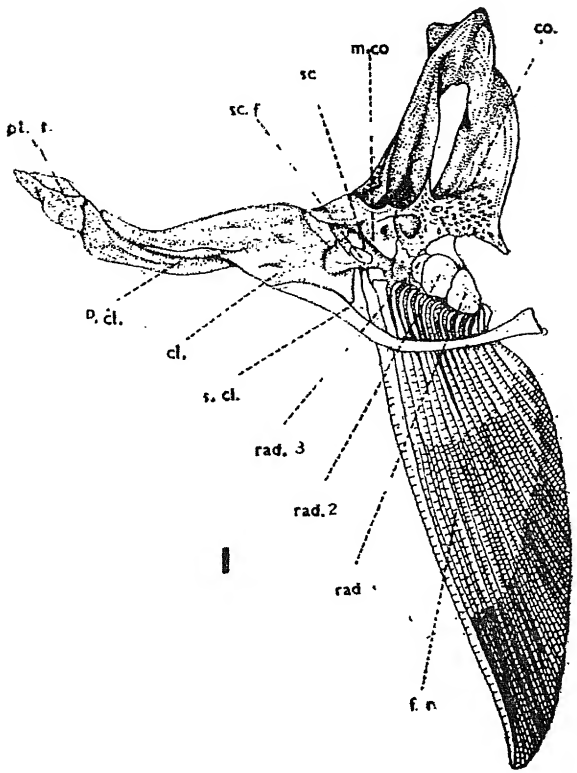
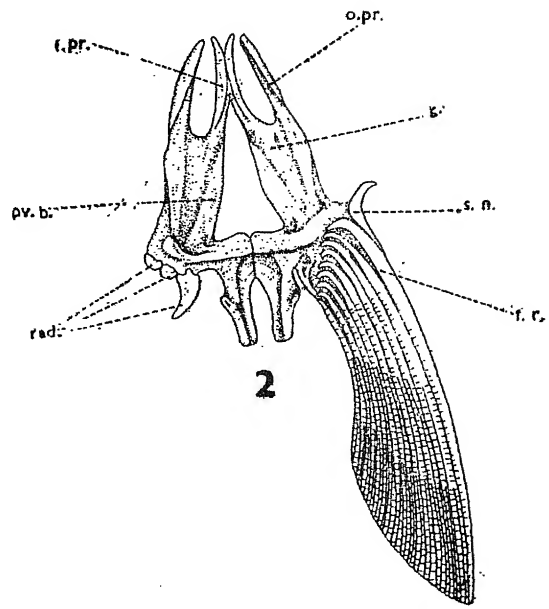
2

PLATE II





2 cm.

PLATE III

most is unbranched and longest, and the rest are branched. The dorsal lobe supported by two epiurals, urostyle and three hypourals, while the ventral lobe is supported by five hypourals. The neural spines of the penultimate and one preceding it vertebrae function as epiurals supporting three fin-rays. The free radial and urostyle support three fin-rays each and the three hypourals support seven fin-rays. Of three hypourals, the first hypoural supports two fin-rays and the second and third hypourals two and three fin-rays respectively. The ventral lobe of fin is supported by five hypourals from the fourth to eighth. The fourth, fifth and sixth hypourals support three fin-rays each, while the seventh hypoural two fin-rays and the eighth hypoural three fin-rays. The notochordal axis of the fin is turned upwards, as such the epichordal lobe is reduced and supports nine fin-rays only and the hypochordal lobe is very much developed and carries the remaining twenty-one fin-rays. Externally this asymmetry is not betrayed and the tail is homocercal.

Discussion

In majority of cyprinids, the articulation between the second and third centra is not visible, but in *Esomus*, *Notropis*, *Ptychochilus*, *Opsariichthys*, *Aphyocypris* and *Aspius* (Ramaswami, 1952-55), it can be clearly made out. According to Mookerjee, Ganguli and Mukerjee (1952) the centra of the first four vertebrae are fused in *Esomus*. The ribs of second vertebra in *Saurogobio* and *Gobiobotia* become broad and in *Cobitidae* (Ramaswami, 1955), they take part in formation of the anterior wall of the capsule (Ramaswami, 1955). In *Gyrinocheilus* (Ramaswami, 1952) and members of Catostomidae (Ramaswami, 1955) there occurs a fusion of the pleural ribs of the second and fourth vertebrae along the centrum of third vertebra, leaving a large paravertebral space, which is extended over by a horizontal shelf covering partially the tripus. From the ribs of fourth vertebra is formed a transverse plate. In *Catla* (Saxena and Khanna, 1962) and *Cirrhina* there is no horizontal shelf, but occurs a paravertebral space. The rest of the vertebral column needs no special comments.

The pectoral and pelvic girdles need no special consideration, except for the variation in the form of pelvic bone. The pelvic bone in the fish is deeply grooved on the dorsal side, while it is flat in *Labeo* (Ramaswami, 1955). The number of rays in the pectoral and pelvic fins is fifteen and nine in *Cirrhina* against seventeen and nine in *Labeo* (Sarbahi, 1932) and *Catla* (Saxena and Khanna, 1952). Among the median fins, the dorsal fin is supported in *Labeo* (Sarbahi, 1932) by fifteen to sixteen fin-rays seated on fourteen radials, which are held by thirteen vertebrae and by nine fin-rays in *Catla* (Saxena and Khanna, 1962). The number of fin-rays in *Cirrhina* is also fifteen to sixteen being supported by fourteen to fifteen radails on twelve vertebrae. The anal fin in *Cirrhina* is formed of eight fin-rays with first three unbranched like *Catla* (Saxena and Khanna, 1962), while by seven fin-rays with first two unbranched in *Labeo* (Sarbahi, 1932). The Caudal fin is homocercal, consisting of a dorsal and a ventral lobe. The number of fin-rays in the dorsal lobe is ninteen in *Labeo* (Sarbahi, 1932), eleven in *Catla* (Saxena and Khanna, 1962) and sixteen in *Cirrhina*. In these forms the incomplete rays are nine in *Labeo* (Sarbahi, 1932), eight in *Catla* (Saxena and Khanna, 1962) and six in *Cirrhina*. The number of hypourals supporting the dorsal lobe of the fin is four in *Labeo* (Sarbahi, 1932) and three in *Catla* (Saxena and Khanna, 1962) and *Cirrhina*. The ventral lobe contains sixteen fin-rays in *Labeo* (Sarbahi, 1932), while in *Catla* (Saxena and Khanna, 1962) and *Cirrhina*, it contains fourteen fin-rays.

Summary

The vertebral column is formed of about forty vertebrae of which the first twenty four found in trunk region and remaining sixteen in the caudal region. In relation to Weberian ossicles the first four vertebrae are fused and form the complex vertebra. In complex vertebra the first vertebra is represented by the centrum and ribs. The second and third fuse into a concave centrum and a common neural arch and a common neural spine. The fourth vertebra is well formed and is of the usual type with large ribs, besides forming a vertical plate from posterior face for the attachment of anterior part of the air bladder. The trunk vertebrae show their parapophyses increasing in size towards the posterior end and a transverse bridge connecting the parapophyses in last two trunk vertebrae. The last three caudal vertebrae are modified in relation with the caudal fin as their neural spines and haemal spines are modified into epiural and hypourals respectively to support the caudal fin-rays.

The pectoral girdle comprises of the reduced primary endochondral part and stout secondary dermal part. The primary part is represented by the scapulae, coracoids and mesocoracoids, while the secondary part is formed of the cleithra, supracleithra, postcleithra and posttemporals. The pelvic girdle consist of two pelvic bones, united by ligament in the middle line. Each bone is produced in front into an inner and an outer process and also bears a groove on the dorsal side. The pectoral fin comprises of the fifteen fin-rays supported on four radials. The first fin-ray is unbranched and longest and the rest are branched. The pelvic fin comprises of the nine fin-rays and a supernumerary supported on three radials. The first fin-ray is longest and unbranched, while the rest are branched. The dorsal fin consist of fifteen to sixteen fin-rays supported on thirteen to fourteen radials. The first and second radials are fused into a single radial supporting the first three unsegmented fin-rays. The proximal, mesial and distal segments of the radial are easily distinguishable in all radials, except the first three. The anal fin is composed of eight segmented fin-rays supported on six radials. The first three fin-rays are unbranched. The caudal fin is of homocercal type. The dorsal and ventral lobes comprise of the sixteen and fourteen fin-rays respectively. Out of sixteen fin-rays only ten in dorsal lobe are complete and out of the fourteen fin-rays in ventral lobe only nine are complete. Six rays in dorsal lobe and five rays in ventral lobe are incomplete and are confined to the basis of their respective lobes. The fin is supported by only two epiurals, a free radial, urostyle and eight hypourals.

Acknowledgements

The present investigations have been carried out under the kind supervinsion of Dr. B. M. Sinha, the then Professor and Head of the Department of Meerut College, and I would like to thank him for his guidance and suggestions.

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Physiological studies of *Cercospora jasminicola* Muller and Chupp. II. Nitrogen Requirements

By

RAM DAYAL & ASHA RAM[1]

Department of Plant Pathology, College of Agriculture, Banaras Hindu University, Varanasi, India

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Introduction

Cercospora sp. are the commonest of the plant parasites but only few of them have been successfully grown on synthetic media. It appears from the literature that little work has been done on the nutritional requirements of *Cercospora* as a genus. Earlier the authors (Dayal and Asha Ram, 1967) have reported the influence of various carbon sources on the growth and sporulation of *Cercopsora jasminicola*. The present paper deals with the influence of various nitrogen sources.

Materials and Methods

Various nitrogenous compounds (inorganic and organic) were added singly to the basal medium* in amount calculated to furnish 700 mgm. of nitrogen per litre. For those compounds of nitrogen whose structural formulae are not known, the amount equivalent to the weight of nitrogen compound in the basal medium was taken. The media were autoclaved at 15 lbs. pressure for 15 minutes and the pH of the media was adjusted to 5·5 before autoclaving. Material for the inoculation was taken from the actively growing colony and the inoculations were made by agar disc method. The incubation period was 15 days and the experiment was run at room temperature (25°C). The degree of sporulation was measured on the basis of visual observations in the slides examined under microscope.

Following nitrogen compounds were tried :

1. *Inorganic compounds* : Sodium nitrate, Sodium nitrite, Potassium nitrate, Ammonium sulphate, and Ammonium tartarate.

2. *Organic compounds* : Urea, peptone, asparagine, and glycine.

Besides these a medium was also prepared without the addition of any nitrogen source.

Observation

The dry weight and degree of sporulation of *C. jasminicola* on various nitrogen sources are recorded in Table 1.

1. *Present address*—Senior research assistant, Division of Mycology and Plant Pathology, I. A. R. I., New Delhi-12.

* *Glucose*—5 gms., KH_2PO_4 – 1·75 gms., KNO_3 – 3·5 gms., $MgSO_4.7H_2O$ – 0·75 gms. and distilled water 1000 ml.

TABLE 1

Showing dry weight, formation of chlamydospores and degree of sporulation of C. jasminicola on medium containing equivalent quantities of different nitrogen compounds

Nitrogen sources	Oven dry wt. (mg.)	Chlamydospore	Sporulation
Sodium nitrate	18·33	–	Moderate
Sodium nitrite	16·66	–	Trace moderate
Potassium nitrate	23·33	–	Moderate
Ammonium sulphate	8·30	Trace	–
Ammonium tartarate	10·00	Moderate	–
Urea	33·33	–	Abundant
Peptone	30·00	–	Trace
Asparagine	36·66	Abundant	–
Glycine	25·00	Moderate	Very trace
Control	5·0	–	–

– denotes absence.

It is clear from the above table that asparagine is the best source of nitrogen followed by urea, peptone, glycine, potassium nitrate, sodium nitrate, sodium nitrite, ammonium tartarate and ammonium sulphate.

Abundant chlamydospores were formed on asparagine, moderate on glycine, ammonium tartarate and ammonium sulphate. No chlamydospores were formed on sodium nitrate, potassium nitrate, sodium nitrite, urea and peptone. It is clear that chlamydospore formation took place only on those nitrogen sources which were incapable of producing sporulation.

The sporulation was abundant on urea, moderate on potassium nitrate and sodium nitrate, trace on peptone and very trace on glycine. There was no sporulation on asparagine, ammonium tartarate, ammonium sulphate and in complete absence of nitrogen. This is clear that there is no correlation between growth and sporulation.

The total growth and degree of sporulation of the organism has been represented in the Histogram.

Discussion

A study of the effect of differant nitrogen sources on growth and sporulation of *C. jasminicola* Muller and Chupp indicates that among inorganic sources of nitrogen best growth and sporulation was obtained on potassium nitrate. In general nitrate nitrogen was most favourable for growth and sporulation amongst inorganic sources of nitrogen due to indirect influence on the pH of the medium. Similar results were obtained by Mix (1933), Neal *et al* (1933), Uppal *et al* (1938), Leben and Keitt (1948), Srivastava (1951), Subramanian Pai (1953), Tandon and Grewal (1956), Mishra and Mahmood (1960), Tandon and Sudhir Chandra (1961) and Berger (1963) for *Phyllosticta solitaria, Rhizoctinia, Phymatotrichum omnivorum, Alternaria burnsii, Venturia inaequales, Colletotrichum papayae, Gloeosporium* sp., *Colletotrichum capsici, Curvularia penisiti*, and *Cercospora zebrina* respectively.

Sodium nitrate supported good growth of the organism studied here. Neal *et al* (1933). Tandon and Agarwal (1957) and Tandon and Bilgrami (1957) obtained good growth of *Phymatotrichum omnivorum* and *Gloeosporium musarum, G. papayae, Fusarium coeruleum* and *Phyllosticta artocarpina* respectively on sodium nitrate but according to Tochniai (1926) it supported poor growth of *Fusarium lini.*

Sodium nitrite also supported fair growth of the present organism. In this respect the result was similar to Tandon and Agarwal (1957), Berger (1963) for *Fusarium coeruleum* and *Cercospora zebrina* but Tandon and Bilgrami (1957) and Tandon and Agarwal (1957) reported that sodium nitrate did not permit any growth of *Phyllosticta artocarpina* and *Fusarium coeruleum* respectively.

Ammonium sulphate was the poorest source of nitrogen for *Cercospora jasminicola*. Similar results with ammonium sulphate were obtained by Patel *et al* (1950), Neal *et al* (1953), Tandon and Grewal (1956), Tandon and Agarwal (1957), Tandon and Bilgrami (1957) and Berger (1963) for *Pestalotia psidii*, *Phymatotrichum omnivorum*, *G. papayae*, *F. coeruleum*, *P. artocarpina* and *C. zebrina* respectively. Hacskaylo, Lilly and Barnett (1954) found that ammonium sulphate restricted the growth of most of species of fungi studied by them but Tandon and Bhargava (1960) reported good growth and excellent sporulation of *Pestalotia* sp. on it.

Ammonium tartarate was poor source of nitrogen for growth and induced no sporulation of the present organism. The authors agree with the results of Berger (1963) for *C. zebrina*.

Among the organic sources of nitrogen good growth and abundant sporulation of *C. jasminicola* was obtained on urea. Similar results were also obtained by Tandon and Agarwal (1957), Tandon and Bilgrami (1957), Tandon and Bhargava (1960), Sethi and Munjal (1963) and Berger (1963) with their respective organisms.

The growth on peptone was moderate even though it supported poor growth of *Alternaria tenuis* investigated by Srivastava (1951). Tandon and Bilgrami (1957), Tandon and Agarwal (1957) and Tandon and Bhargava (1960) reported that peptone was the poor source for *F. coeruleum*, *P. artocarpina* and *Pestalotia* sp.

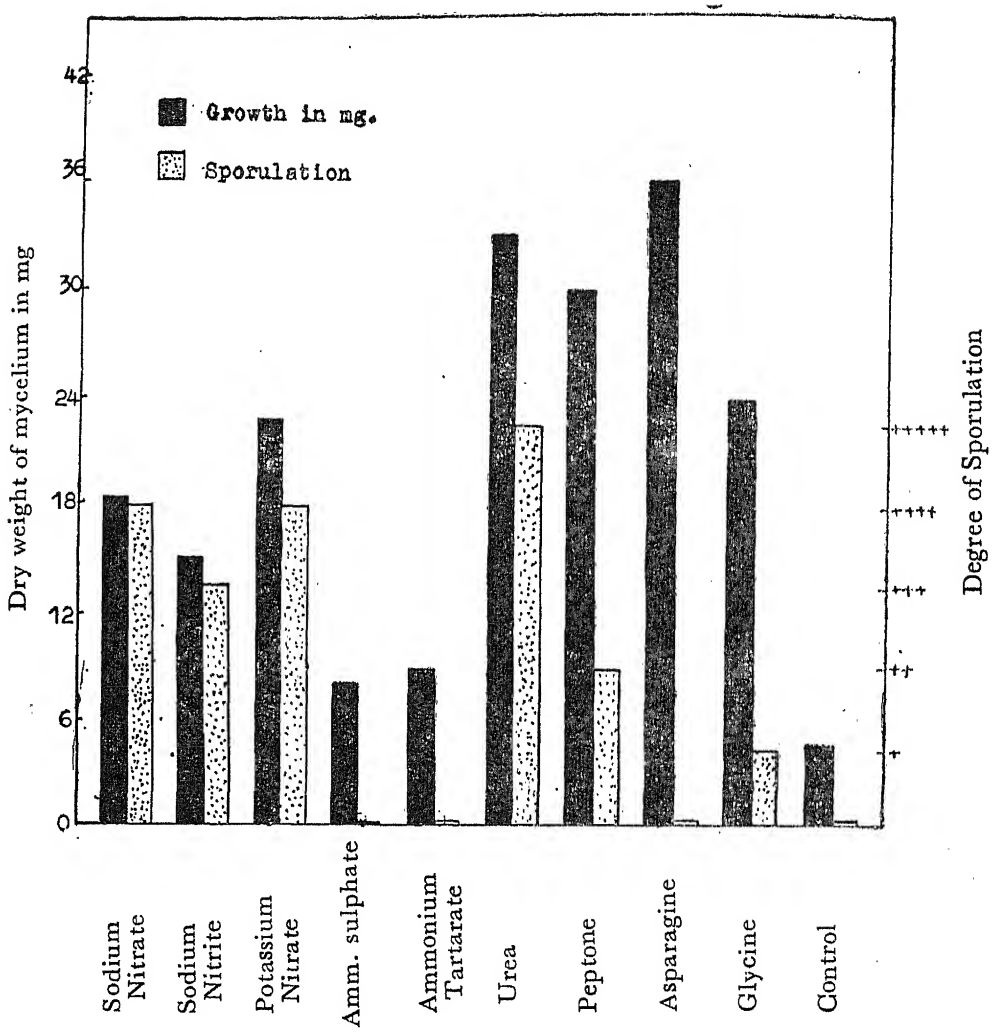
Asparagine was the best source of nitrogen among all nitrogen sources tested but induced no sporulation. Saksena and Kumar (1960), Agarwal (1962), Chandwani and Munjal (1963), Sethi and Munjal (1963) and Berger (1963) found that the asparagine was the best source of nitrogen and induced sporulation of *Pestalotia* sp., some species of Sphaeriopsidales, *Gloeosporium carissae*, *Helmithosporium gramineum*, *Cercospora veticola* and *C. zebrina* respectively.

Glycine supported good growth of *C. jasminicola*. Similar results were obtained by Gottlieb (1964), Wolf *et al* (1950), Converse (1953), Tandon and Agarwal (1957) and Berger (1963) for *Fusarium oxysporum*, *Monosporium apiospermum*, *H. gramineum*, *F. coeruleum* and *C. zebrina* respectively.

The nitrogen sources which were best for vegetative growth were not the same for the sporulation of the fungus. There was no correlation between good growth and sporulation of the fungus. Lilly and Barnett (1951) have also observed that sporulation of some fungi is favoured by certain source of nitrogen which are not necessarily the same as those which are favoured for growth. It was also observed that the chlamydospore formation took place only on those nitrogen sources which were incapable of producing sporulation. Negligible growth and sporulation of the fungus was obtained in complete absence of nitrogen.

Summary

The influence of different nitrogen sources on the growth and sporulation of *C. jasminicola* Muller and Chupp isolated from the leaves of *Jasminum sambac* Ait was studied. The nitrogen nutrition of *C. jasminicola* has not been studied by any worker so far. The study was carried out at room temperature. Initial pH of the medium was adjusted to 5·5. Asparagine was the best source of nitrogen for



Histogram showing growth and sporulation of *Cercospora jasminicola* Mullur and Chupp on various Nitrogen Sources.

the mycelial growth of the fungus but abundant sporulation occurred on urea. Other good nitrogen sources were urea, peptone, glycine and potassium nitrate etc. Negligible growth and no sporulation of the organism was obtained in complete absence of nitrogen. The nitrogen sources which were best for vegetative growth were not the same for sporulation of the organism. Chlamydospore formation took place only on those nitrogen sources which were incapable of producing sporulation.

Acknowledgement

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*Original not consulted.

THE

National Academy of Sciences, India

THIRTY-EIGHTH ANNUAL SESSION

RANCHI, March 17–19, 1969

PROGRAMME

NATIONAL ACADEMY OF SCIENCES
LAJPATRAI ROAD
ALLAHABAD
1969

PROGRAMME

MONDAY, 17th March, 1969

2-30 p. m. Inauguration and Annual Meeting (Ranchi College Hall).

1. Bande Mataram.
2. Appointment of two scrutineers by the President to count votes.
3. Reading of Messages by the General Secretary.
4. Welcome Address by the Chairman of the Reception committee.
5. Annual Report by Prof. M. D. L. Srivastava, General Secretary.
6. Inaugural Address by Dr. A. C. Joshi, Vice-Chancellor, Banaras Hindu University.
7. Presidential Address by Dr. R. K. Saksena, President of the Academy.
8. Presentation of Uttar Pradesh Education Minister's Gold Medal.
9. Announcement of Office-bearers for 1969 by Prof. M. D. L. Srivastava, General Secretary.
10. Vote of thanks to the Chief Guest by the President.
11. Vote of thanks to the Ranchi University by the General Secretary.
12. National Anthem.
13. Group Photograph of Guests, Members and Delegates.

4-30 p.m. At Home : by the Reception Committee (by invitation)

6-00 p.m. Popular Lecture (Ranchi College Hall)—Coal resources of India by Dr. A. Lahiri, Director, Central Fuel Research Institute, Dhanbad.

6-45 p.m. Popular Lecture (Ranchi College Hall)—Use of w astelands by Dr. S. P. Raychaudhuri, Chief Agronomist, Sri Ram Mills, Delhi.

7-30 p.m. Entertainment.

9-00 p.m. Dinner.

TUESDAY, 18th March, 1969

PRESIDENTIAL ADDRESSES (Ranchi College Hall)

9-00 a.m. to 10-00 a.m. 1. *Section of Physical Sciences* : Prof. P. L. Bhatnagar, Indian Institute of Science, Bangalore.

10-00 a.m. to 11-00 a.m. 2. *Section of Biological Sciences* : Prof. U. S. Srivastava, University of Bihar, Muzaffarpur.

11-00 a.m. to 11-30 a.m. Coffee break.

SECTIONAL MEETINGS

11-30 a.m. to 1-00 p.m.	1. *Physical Sciences* : Presentation of contributed papers and discussion (Room No. 86).
	2. *Biological Sciences* : Presentation of contributed papers and discussion. (Room No. 84).
1-00 p.m.	Lunch
2-30 p.m. to 4-30 p.m.	Sectional meetings continued.
5-00 p.m.	'At Home' (by invitation).
6-00 p.m.	1. Popular Lecture 'Science and civilization' by Prof. N. R. Dhar.
6-45 p.m.	2. Popular Lecture 'Theory of Relativity' by Prof. R. S. Mishra, Banaras Hindu University.
7-30 p.m.	Entertainment (by invitation).
9-00 p.m.	Dinner.

WEDNESDAY, 19th March, 1969.

9-30 a.m. to 12-30 p.m.	Sectional meetings : Presentation of contributed papers and discussion.
	(*a*) *Physical Sciences Section.* (Room No. 86)
	(*b*) *Biological Sciences Section.* (Room No. 84)
1-00 p.m.	Lunch.
2-30 p.m. to 5-00 p.m.	Excursion (Heavy Engineering Corporation).
5-30 p.m.	'At Home' (by invitation).

THE

National Academy of Sciences, India

THIRTY-EIGHTH ANNUAL SESSION

RANCHI, March 17-19, 1969

GENERAL PRESIDENTIAL ADDRESS

Mycology in India

By

R. K. SAKSENA, M.Sc. (B. H. U.), Dr. ès Scs. (Sorbonne), F.N.A.Sc., F.N.I.
Retired Professor of Botany, University of Allahabad, Allahabad.

NATIONAL ACADEMY OF SCIENCES
LAJPATRAI ROAD
ALLAHABAD
1969

PRESIDENTIAL ADDRESS

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Retired Professor of Botany, University of Allahabad, Allahabad.

LADIES AND GENTLEMEN,

I am thankful to the members of the National Academy of Sciences for the honour they have done me by electing me their President for the year 1968.

Though some time has passed when I retired from active scientific pursuits yet I try to keep contacts with my students and younger colleagues. Naturally, I am delighted at their achievements and revelations of new facts but sometimes I feel sorry also to see some hasty publications. Since in this audience are scientists of different desciplines, I shall try to be as simple in my presentation as possible.

For many years I had been interested in a group of organisms called fungi which are claimed by both botanists and zoologists as belonging to their domain. Some people have even begun to think that they belong to a kingdom of their own. The common moulds that we often come across on spoiled or decomposing organic matter such as food stuffs, fruits and vegetables, pickles, the mushrooms that are curiosities of the children, some of them being really delicious and others deadly poisonous, and the wood destroying bracket-like organisms, are all fungi. Like us they also do not contain the green colouring matter (chlorophyll) hence they are also unable to manufacture their own food. But they differ in their mode of nutrition in that they digest the food first and then suck it in their body, while we take in the undigested food, whatever is more palatable, and then digest it later as much as we can inside our body. Possibly we would have done better if we could do the same as fungi do because then there would have been no question of constipation, a condition which attracts other diseases.

These organisms reproduce both asexually as well as sexually. Some of them have well developed reproductive organs while others, believed to be more advanced, have retained only essential features of all sexual processes, *viz.*, the fusion of two compatible nuclei and subsequent meiosis of the diploid nucleus.

The fungi were once looked down by man as obnoxious agents of disease and decay but now they have acquired a place of respect and admiration even in the eyes of the lay man. Since the dawn of history fungi have been decomposing, along with their partners the bacteria, the huge amount of organic waste that is thrown out from every house every day. Had they not being doing so, there would have been left no proper place for us to live by now.

Yeasts, the smallest of the fungi, have been fermenting sugary solutions to produce alcohol since time immemorial. They now serve as a useful source of proteins and vitamins for the starving millions of the world. Also many of the higher fungi produce their fruit bodies large and delicious enough to serve as a source of food, *e.g.*, morels (Morchellas), Clavarias, truffles (Tubers), etc. In foreign countries some of these are being grown and cultivated on a large scale just as other vegetables. However, few of these mushrooms contain dangerous poisons and are known to produce hallusinogenic substances which produce ecstatic effects in men. These hallusinogenic principles have been isolated and they are being used in experiments to study certain mental illnesses. Fungi are being used in processing of food, for example, *Penicillium camemberti* for Camembert cheese, and *Penicillium roqueforti* for Roquefort cheese. The role of fungi in medicine is not hidden even from the common man. He can never repay the debt which he owes to the penicillin producing mould, *Penicillium chrysogenum*, for saving considerable

number of the human race from death and disease during war and peace. Even those who might not have taken a dose of penicillin yet they know the wonderful curative properties of this drug which has produced a revolution in the healing arts. Also, ergot, a drug long in use for obstetric purposes to induce uterine contractions in cases of delayed child birth is of fungus (*Claviceps purpurea*) origin. Fungi are now well recognized as capable of inducing such chemical transformations which man with all his ingenuity finds difficult to bring about. Synthesis of steroides (organic compounds produced by endocrine glands—testes, ovaries and placenta of pregnancy) is now possible with the help of a number of microorganisms particularly fungi. This has resulted into an entirely new branch of chemistry. Some of the fungi have wonderful capacity to convert carbohydrates into useful acids. Citric acid which is utilized in enormous quantities in all advanced countries of the world is mostly produced by fermentation, brought about by a strain of a black mould, *Aspergillus niger*.

Not only the fungi are being utilized for food and industry but they are serving as important tools by cytologists, geneticists and biochemists to reveal the intricate details of their life history, inheritance of characters, and to attack biochemical problems which are not so easy to tackle in other microbial, plant and animal systems. *Neurospora* is one such fungus which has been used extensively by geneticists because of its relatively simple nutrition, a short generation time and self sterility which permits the mating of control crosses.

Mycology, the science of fungi, began in India with stray collections of fungi by foreigners and later their identification and studies in foreign laboratories. Hooker and Thompson made an intensive collection of the mushrooms (Agarics) from the Eastern Himalayas and these were described by Barclay. Large number of fungi from Bengal and Burma were collected by Kurz and these were studied and reported by Currey. Later D. D. Cunningham from 1871 to 1896 and Barclay from 1889–1892 investigated a number of fungi in India belonging to the orders Mucorales, Ustilaginales and Uredinales (rusts). One of the first Indians to make a systematic study of fungi was K. R. Kirtikar who studied fleshy fungi of India during the later part of the 19th century. However, it was E. J. Butler whose arrival in India in the year 1905 as the Head of the Imperial and now Indian Agricultural Research Institute, New Delhi ushered a new era in the progress of Mycology and Plant Pathology in India. His book on plant pathogenic diseases in India is an exhaustive treatment and can not be replaced easily for years to come. During his 20 years stay in India and later after his departure in 1921 a number of trained mycologists and plant pathologists have been actively busy in various centres in India. During the early part of this century was at Allahabad, J. N. Mitter whose inspiring interest in general mycology specially taxonomy of fungi led to the establishment of a school of mycology and plant pathology in the Botany Department of the University of Allahabad. For a number of years myself and R. N. Tandon have run this school and have been responsible for establishing new traditions. Some notable contributions have been made in India concerning the morphology and taxonomy of fungi.

The slime molds (Myxomycetes), which have an amoeboid mass of protoplasm as their vegetative body, are claimed as falling in their domain by both the students of plants and animals. This group is of little economic importance but has interesting morphological features. In the past it has been studied by a number of workers and more recently by K. S. Thind. However, much more work has to be done on these organisms for their naked, multinucleate plasmodium offers great promise as an experimental material both for biochemists and biophysicists for studying stimulus response and protoplasmic syntheses. Their plasmodia can be chemically analysed without complication of nonliving cellulose walls.

The lowest group of the true fungi, the class Phycomycetes, has attracted the attention of many Indian mycologists. The chytrids, the lowest of the aquatic Phycomycetes have received very little attention in this country. The genera

Synchytrium and *Physoderma* have however been studied extensively (by M. J. Thirumalachar, B. T. Lingappa, and others). The most important genus of the Blastocladiales, *viz.*, *Allomyces* was established in India by E. J. Butler. It has been found to be of great interest to morphologists and geneticists subsequently. S. N. Das Gupta and Rachel John studied some members of this order as well as those of the Monoblepharidales and Lagenidiales. The Saprolegniales, a prominent aquatic group of the Phycomycetes, has been studied more intensively with regard to their physiology and cytology by myself and my associates (K. S. Bhargava, M. S. Murdia and others). Among the Peronosporales the genera that have been studied most in India are : *Albugo* (both life history and cytology of a few species by K. M. Safeeulla and M. J. Thirumalachar), *Pythium* and *Phytophthora* (mostly cytology and physiology by R. K. Saksena and his associates). The two important obligate parasites *Sclerospora* and *Peronospora* were studied by B.N. Uppal and K.S. Thind respectively. A new genus *Sclerophthora* combining the characters of *Phytophthora* and *Sclerospora* has been described by M.J. Thirumalachar, M. J. Narasimhan and C.G. Shaw in 1953.

The Mucorales, a group of mostly saprophytic and terrestrial fungi of the class Phycomycetes was very much neglected in India in the past. In 1953 S. B. Saksena described a remarkably new genus of this order, *Saksenaea*. Only a single species of this genus is known so far and inspite of best efforts no zygospores have been found. It is peculiar physiologically also as it does not sporulate under nutritional conditions under which most Mucorales do. A synthetic medium for growth and sporulation was not known till recently when Usha Baijal reported that a synthetic medium containing such carbon sources as arabinose, rhamnose, sorbose, galactose, lactose and citric acid, which support poor growth can support good or even excellent sporulation in this organism. Much work has been done in recent years on the Mucorales of India at Allahabad by my former student, B.S. Mehrotra and his associates. Several significant additions have been made to the order. Recently the *Blakeslea* and *Choanephora* controversy first started by S. Sinha (1940) seems to have been finally settled by B. S. Mehrotra and Baijal with the help of their new species *B. monospora*. They have justified the retention of the genus *Blakeslea*. The Mucorales are an interesting group of organisms both from the point of view of variety of morphological characters they exhibit and also because some of them are of industrial value also.

As compared to other groups of the fungi, the Ascomycetes have not received much attention of the Indian mycologists. The yeasts have been completely neglected except for some interesting cytological observations made by M. K. Subramaniam and his associates. To the powdery mildews have been added a genus *Astomella* by M. J. Thirumalachar and to Sphaeriales a genus *Bagcheea* by E. Muller and R. Menon in 1954. A number of the Pezizaceae and some of the Helotiaceae have been reported by K. S. Thind and his coworkers. Except for reporting a number of genera from different localities no significant contribution seems to have been made with respect to the Ascomycetes in India.

Among the 'lower' Basidiomycetes, the important plant pathogens, the smuts and the rusts have been extensively studied in India chiefly by B. B. Mundkur and M. J. Thirumalachar. A number of significant contributions describing a number of new genera and species have been made by them. K. D. Bagchee studied the rusts of Indian conifers and discovered the alternate hosts of several of them. Out of the 'higher' Basidiomycetes, the coral fungi (Clavariaceae) have been reported by K. S. Thind in a recent (1962) monograph. The Thelephoraceae have been studied by S. N. Banerji in 1935. Pioneering work on the polypores of India, particularly that of Bengal, has been done by S. R. Bose. Many of the higher Basidiomycetes such as that of the order Tremellales and Agaricales have still to be revealed.

Of the imperfect fungi (Deuteromycetes) only some of the genera have been studied more intensively. Of special mention are the works of T. S. Sadasivan on *Fusarium*, of C. V. Subramaniam on a number of Hyphomycetes, of M. Mitra on

Helminthosporium, of M. J. Thirumalachar and associates, on *Cercospora*. Recently R. N. Tandon and his associates have reported a number of imperfect fungi chiefly of Sphaeropsidales and Melanconiales from decaying fruits and as leaf spot fungi. He and his associates have done much work on the physiology of some fungi. The Aspergilli and Penicillia are being studied more intensively at Allahabad by B. S. Mehrotra and his students. Few new species have been reported. Many new habitats such as marine waters, and foam, sillage waters have yet to be explored for little known or not yet reported imperfect fungi.

That mycology is a dynamic descipline, playing a substantial role in the development of biological concepts and theories in development of agriculture and medicine, is well recognized. In recent years a large number of new fields of investigation in mycology have grown up. In the field of taxonomy and morphology of fungi a lot more has to be known inspite of the fact that approximately 23,400 new taxa have appeared in the last decade. It has been estimated that it will take nearly 50–75 years to reveal the total number and variety of fungi in the world Inspite of intensive activity in certain groups of fungi in India many more are still to be revealed. Though there has been an increase in the number of mycologists in India yet this increase has been much less in number as compared to many advanced countries of the world. Taxonomic mycology is gaining ground inspite of general criticism of morphological work, for on the correct identification of the organism depends the success of a fermentation industry and the success of a plant pathologist. To facilitate identification of some difficult groups of micro-organisms, mycologists or microbiologists are now resorting to neumerical taxonomy and are taking the help of computors. In India we have yet to start such intensive taxonomic studies.

The role of a mycologist in several fermentation industries is yet to be realised to the full in India. We still have very few fermentation industries as compared to such countries as U. S. A., U. S. S. R., Japan, etc. The result is that we are still importing many of the products of fermentation by micro-organisms. To quote an example, we are still importing huge quantities of citric acid. It is now time that a team of mycologists and biochemists should join hands to establish suitable fermentation industries to meet the growing needs of our country. The role of a mycologist in agriculture is in no way smaller than that of a plant pathologist for on the correct identification of the causal fungus depends the success of the plant pathologist. Medical mycology is still in its infancy in India. Some good work has been done under M. J. Thirumalachar at Pimpri, Poona, and H. K. Baruah at Gauhati. We have yet to have a group of good medical mycologists. The importance of fungi in causing disease in man and animals, is now well realised. Diseases by fungi though infrequent are equally dangerous and difficult to cure. Thus there is much scope for research in medical mycology in India for which medical doctors, mycologists and persons dealing with animal husbandry should work in close collaboration.

It is true that a morphological-taxonomic approach should form the basis of a study of fungi but we ought to include in courses of mycology the physiological, biochemical, genetical and economic aspects of fungi which have brought mycology to its present high status.

Before I close I would like to give a note of warning to our colleagues in mycology. In recent years there has been a tendency to merge mycology with microbiology and even in International Botanical Congress there is now no mycology Section. It has also been the general experience that in microbiological conferences there is a dominance of bacteriologists. Naturally under such circumstances the cause of mycology is bound to suffer and to safeguard it we ought to be more assertive.

In the end I thank you all for kindly giving me a patient hearing.

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SECTION OF BIOLOLOGICAL SCIENCES

PRESIDENTIAL ADDRESS

By

PROF. U. S. SRIVASTAVA, M.Sc., D.PHIL., D.I.C.(LOND.), F.N.A.Sc.
Department of Zoology, Bihar University, Muzaffarpur

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1969

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PROF. U. S. SRIVASTAVA, M.Sc., D.PHIL., D.I.C.(LOND.), F.N.A.Sc.

Department of Zoology, Bihar University, Muzaffarpur

I deem it a great honour to have been asked to preside over the meetings of the Biological Section of this session of the National Academy of Sciences of India and I express my feelings of deepest gratitude to the Council of the Academy for the favour done to me.

I propose to talk today on certain aspects of insect endocrinology, a field of entomology which has made phenomenal progress during the last twenty years or so. I have chosen this subject not only because of my personal or parochial interest as an entomologist, but also because some of the very latest findings in this area promise to throw light on certain problems which are, on the one hand, of great fundamental interest to biologists as such, and on the other, of considerable economic importance.

It is now fully established that the postembryonic development of insects is stimulated, oriented and controlled by hormones. In insects, this development differs from that of most higher animals in two important respects. Firstly, it is not a continuous process, but is accomplished in a series of steps, which resolve the life of the animal into several stages or stadia, separated from one another by intense physiological activity, culminating in a moult or ecdysis during which the old cuticular covering over the epidermis is shed off and a fresh one secreted. The fresh cuticle is soft and allows for growth in the body size which was prevented by the previous, hardened cuticle. The earlier moults do not result in any significant morphological change —a larval instar leads into the next, similar though larger, larval instar ; but the last two moults in the case of the Holometabola (larval-pupal moult and pupal-adult moult) and the last moult in the case of Hemimetabola, bring about large scale morphological changes, which cumulatively constitute the metamorphosis. Secondly, the larvae of most insects are far more different from their respective adults than in any other animal group and hence the morphological and physiological changes involved are much more vigorous and acute. One has only to picture the difference between a maggot and a fly or a caterpillar and a butterfly to conceive the magnitude of transformation required in such a metamorphosis.

The periodic moulting and all the morphological changes associated with it, and growth are controlled by two hormones, one produced by a mass of neurosecretory cells in the dorso-medial part of the brain, and hence called the "brain hormone" and the second secreted by certain cells forming a pair of irregular glands of diverse shape and situated in the prothorax and called the prothoracic glands. Travelling via the blood, the brain hormone stimulates the prothoracic glands which now release their own hormone. This hormone acts on their "target cells", causing them to grow and divide. The epidermal cells also may grow and divide under the influence of this hormone, but they invariably deposit a fresh layer of cuticle and discard the old one. Thus moulting occurs. Hence the prothoracic gland harmone has been called the moulting hormone or

"ecdysone" (Butenandt and Karlson, 1954). Since the prothoracic glands are concerned specifically with moulting, one would imagine that they have no more part to play once metamorphosis has been completed and the insect no longer moults. This indeed is the case and in fact, after the prothoracic glands have secreted enough hormone to bring about and complete the last moult, they are no longer needed and actually disappear (Wigglesworth, 1954 ; Srivastava, 1959). In the Apterygota, however, in which moulting continues throughout, the prothoracic glands also persist. Thus the prothoracic gland is a true growth and moulting hormone of insects.

What makes a larval instar moult into another larval instar or into a pupa ? The answer to this question lies in the third endocrine organ, a pair of small glands called the corpora allata which are situated close to the brain of the insect. Long ago, the celebrated insect physiologist V. B. Wigglesworth (1936) had shown that these glands secrete a hormone which prevents metamorphosis, although it promotes larval development. By surgically removing these glands, an early larval instar can be made to pupate precociously, while its implantation in the last larval instar under appropriate conditions would produce an extra larval moult. It is thus evident that the hormone produced in the corpora allata has the remarkable property of permitting, or even promoting growth, but at the same time preventing maturation. It is now established that by some mysterious mechanism, the corpora allata, which become active along with the prothoracic glands at the time of initiation of each larval moult, become inactive and cease to produce any secretory material at the onset of metamorphosis. Hence this hormone has rightly been called the "juvenile hormone". Later studies have confirmed that the titer of juvenile hormone in the blood is of utmost importance in the determination of the outcome of moult in insects. When the larva is stimulated to undergo a moult by the moulting hormone, the presence of a high concentration of juvenile hormone in the blood causes the body tissues to produce, once more, the same larval tissues, *e.g.* the epidermis again produces another layer of larval cuticle ; when the juvenile hormone is in a small quantity, the same epidermal cells give rise to pupal cuticle ; and when the juvenile hormone is absent, these cells may directly secrete adult cuticle, by-passing altogether a pupal moult. Thus while a young insect stage undergoes a moult under the influence of the brain hormone and moulting hormone, what this stage would moult into is decided under the influence of the juvenile hormone (Gilbert, 1964).

As in the case of the moulting hormone, again it might be inferred from the above that once an insect larva is ready to be transformed into an adult, the corpora allata, *viz.* the structures responsible for retaining the larval characters, will no longer be required and would disappear. This, however, does not happen. The corpora allata are retained and after metamorphosis is complete, they become active again and control maturation. In many adult insects, it has been clearly demonstrated that the juvenile hormone – or the secretion of the corpora allata, if the term juvenile hormone is considered inappropriate for a substance that causes adult maturation – regulates the maturation of eggs in the females and the accessory reproductive glands in the male. That it also influences important metabolic processes is also clearly indicated.

The clear-cut picture of the endocrinal mechanism of moulting and metamorphosis drawn in the aforesaid is true in a very large measure, but there are several anomalies and deviations which raise important and interesting questions. Besides, the known facts, as they are, compel certain issues to be put under the spotlight for proper understanding.

To begin with, students of embryology would be inrigued to note that inspite of the different roles that the three endocrine glands referred to here play, all the three, *viz.*, the neurosecretory cells, prothoracic glands and corpora allata are ectodermal in origin and the last two actually arise from adjacent embryonic segments. Further, by electronmicroscopic studies Gilbert and Berta Scharrer (See Gilbert, 1964) have shown that cells of the prothoracic glands and corpora allata are so similar as to be virtually indistinguishable and their endoplasmic reticulum resembles each other as well as that of the mammalian endocrinal cells engaged in steroid metabolism.

Again, inspite of different functions, the three hormones are closely related chemically. Kobayashi and his coworkers (1962), after immense labour (they dissected out no less than 220,000 brains of silkworm pupae te proceed with their chemical analysis !) concluded that the crystallised brain hormone is identical with cholesterol. From the work of Karlson and his associates (1954 and 1963) it had become clear that the moulting hormone consists of two fractions, designated α ecdosone and β ecdysone respectively and that both are steroidal in nature. And recently, Roller and his collaborators (1967) have eludidated the chemical structure of the juvenile hormone and described it as an ester. Thus all the three hormones belong to the same class of compounds and may be produced at one stage or another during fat metabolism. The similarity in the ultrastructure of the endocrine glands, therefore, does not seem at all surprising.

That these hormones are closely related is also indicated by certain observations which may be regarded to be deviations. For instance, Gilbert and Schneiderman (1959) and Williams (1959) showed that the implantation of the corpora allata or injection of juvenile hormone caused brainless moth pupae to moult, indicating clearly that the juvenile hormone can stimulate the prothoracic glands to release their own secretion. Likewise, long ago, Chadwick (1956) had shown that even after complete removal of the prothoracic glands before the critical period, several nymphs of cockroach did moult, that is moulting took place without ecdysone. Chadwick's observation was viewed with much scepticism, but recentyl Ichikawa and Nishiitsutsuji-Uwo (1960) have again demonstrated that the brain hormone alone or the juvenile hormone alone may substitute for ecdysone and bring about moulting in isolated abdomens of certain insects which contained no known endocrine glands. Similarly Kobayashi and Burdette (1961) have shown that isolated fly abdomens which had received minute doses of ecdysone, otherwise insufficient to cause moulting, would undergo a moult if administered cholesterol preparations with brain hormone activity. The substitution of one hormone by another in these examples raises important questions regarding their manner of action. Do they undergo some kind of a convergent chemical change in the organism's system before acting upon the target cells ?

The fact that the secretion of the corpus allatum performs different functions in the larva and adult—preventing adult development in the former and promoting maturation in the latter—naturally leads to the suspicion that these glands produce different hormones in the two stages. However, Williams dispelled this doubt when in 1956 he prepared the first extract of juvenile hormone from the abdomens of adult male cecropia moths and showed that it had potent and typical juvenilizing effect in the immature stages. It may, therefore, be taken for granted that the corpora allata produce the same hormone in the larva and the adult of an insect. The question naturally arises how the same substance influences the cells in these distinct ways in the different stages. Is the difference brought about by the accompanying presence of the moulting hormone, or do the cells react

differently to the same substance in the different stages?. This might be an interesting problem for the molecular biologist to investigate.

Another moot point exists regarding the neurosecretory cells. Histological studies have shown that besides the pars intercerebralis of the brain, cells of which have been attributed the function of producing the brain hormone, other parts of the brain also possess neurosecretory cells and the suboesophageal ganglion and other ganglia are also not lacking in these. Besides the neurosecretory cells of the pars intercerebralis can be distinguished into distinct types on the basis of their staining reactions. (Gildiay, 1959 ; Prasad, 1962). It has been suggested that in the adult insect, neurosecretory cells in the different parts of the central nervous system undergo independent secretory cycles, indicating that they are associated with different functions (Srivastava and Prasad, 1966). On the whole, however, very little attention has been paid to these questions and the significance of the observations remains far from understood.

The large-scale physiological control of the various processes of differentiation during the post-embryonic development of insects by the different hormones clearly indicates that these substances act in a fundamental manner on the organisms, and possibly directly on the genetic material itself. The easy manipulation of the insect material and now the purification of the hormones, have made investigations in this direction fruitful and uncommon interest has been aroused among workers.

It has been assumed for long that the various changes occurring in the different tissues during the development of an organism are controlled by the activation or inactivation (depression) of different genes. However, experimental support for this view came only when Beerman (1952), Breuer and Pavan (1954, 1955), Kroeger (1960) and others described characteristic swellings or puffs in certain segments of the giant chromosomes of the salivary glands and other tissues of Diptera and when in several studies the "puffing pattern" was found to be correlated with the developmental changes of the organism (Chen, 1958). Studies with tritiated uridine and labelled aminoacids have also revealed that active synthesis of messenger RNA takes place in the puffed regions of chromosomes. Thus it may be concluded that the changing behaviour and biochemical activity of cells during development may be caused by the differential activation or suppression of specific genes (Beerman, 1959).

Talking specifically in terms of the action of ecdysone, which initiates and regulates postembryonic growth and moulting in insects, one would imagine that the principal target of the hormone is the nucleus itself wherein it activates certain specific chromosomal regions or sets of genes. If so, ecdysone would cause chromosomal puffing associated with the synthesis and release of such messenger RNA as can bring about and/or participate in cytoplasmic syntheses characteristic of the processes of growth and moulting in insects. Indeed this view seems to be strongly indicated by the studies of Clever and Karlson (1960) in *Chironomus*. They found that changes in the puffing pattern characterising pupation occur in the chromosomes shortly after injection of pure ecdysone.

Similar studies in differential puffing have been made by Becker (1962) in the salivary gland chromosomes of *Drosophila* during the last larval instar, as well as in prepupal and pupal instars. By ligating the larvae so as to divide it into two compartments, he found that the chromosomes of those salivary gland cells which were in the same compartment as the source of the moulting hormone, showed the specific "prepuparium" puffing pattern. When he implanted the salivary glands of an early last instar larva into a late last instar larva, he similarly found precocious appearance of "prepuparium" puffing pattern in the

chromosomes of the implant. Even more interesting was the observation that when salivary glands of prepupae were implanted in the last instar larvae, there was a repetition of the "prepuparium" puffing pattern in the implant. This latter observation seems to explain to some extent the production of super-larvae and pupal-adult intermediates as well as the appearance of larval cuticle on adult epidermal cells under proper hormonal conditions.

In his subsequent detailed studies on *Chironomus*, Clever (1961*a*, 1961*b*, 1962*a*, 1962*b*) noted that within 15 to 30 minutes of injecting ecdysone, the first puff which is characteristic of the onset of the pupal stage, makes its appearance in a specific region. Between 30 to 60 minutes, a second puff appears which is also seen in the normal "prepupal condition". Subsequently, other puffs appear. Clever concludes that only two of these several puffs are involved in puparium formation, while the others depend partly upon these "primary" puffs, or are related to subsequent developmental changes. In other words, certain primary puffs, in turn, cause to produce some other puffs. He also observed that the size of the puffs depends upon the quantity of the hormone injected and the maintenance of a puff depends upon the continued presence of a certain minimum titer of the hormone in the organism. Clever thus concluded that the first and most direct effect of ecdysone on *Chironomus* is to activate one particular gene or perhaps a group of genes.

Impressive as these observations are, they raise more questions than they solve, the chief among which is "how does ecdysone act on the chromosomes'? A few recent studies tend to throw some light on this vital question. In a series of experiements, Kroeger (1963*a*) has shown that several chemical substances, like zinc chloride, cadmium chloride, narcotics, chloroform, butanol, etc., produce the same kind of puffs in the salivary gland chromosomes of *Chironomus* as ecdysone, although these substances cannot bring about moulting and pupation and seem to act regardless of the amount of hormone already present. In other words, they do not increase the sensitivity of the organism to the existing hormone. By intricate microsurgical manipulation, he also demonstrated (1963*b*) that a chromosomal puff responded independently of other gene loci, suggesting that the puffs result from a change in the intranuclear environment, possibly through some kind of a change in the nuclear membrane rather than the activation of a preexisting puff which, in turn, may produce another puff and so on. From these observations, Kroeger inferred that ecdysone does not have a direct effect on the DNA molecule and that an intermediate system exists somewhere in the cells that links the hormone action to the chromosome effect. He inferred that the immediate factor influencing the puffing activity of the chromosomes is an alteration in the balance of Na^+ and K^+ ions in the nucleus, which itself is brought about by these agents and adduced evidence in support of his contention by experiments involving changes in the concentration of these ions. It follows then from Kroeger's work, that the "control system" influenced by ecdysone is the one which determines the Na^+/K^+ ratio in the nuclear sap ; that in some specific manner ecdysone brings about changes in Na^+/K^+ ions, *viz.*, in the permeability of the nuclear membrane. This would mean that puffing is the result of a high K^+ concentration in the nuclear sap. Although Kroeger's work may explain the immediate causes of puffing, it raises another serious problem ; whereas various chemicals produce the same puffs in the giant chromosomes as normally accompany pupation, nevertheless, they cannot bring about pupation. In other words, while these substances act upon the nucleus in the same way as ecdysone as far as the production of certain puffs is concerned, they cannot go to the extent of making the puffs start the physiological processes characteristic of ecdysone administration. How do these physiologically inactive puffs differ from the physiologically active ones ?

Notwithstanding Kroeger's observations, there is some evidence that ecdysone acts directly at the nuclear level in the target cells. Karlson and Sekeris (1962), for example, used labelled ecdysone and found that the substance does accumulate in the nucleus of the epidermal cells. When injected, the level of ecdysone first rises in the blood of fly, then the substance accumulates in the epidermis and is finally deposited in the fat body. The epidermal nuclei show maximum activity while the microsomes of the fat body are also heavily labelled. These workers conclude that the site of action of ecdysone is epidermis while the deposition in the fat microsomes is there to get rid of the excess of the hormone. A little later, Laufer and Nakase (1964) showed that there is a definite correlation between puffing pattern of the giant chromosomes of *Chironomus* and changes in the synthesis of specific enzymes like actinomysin D. This substance, known to inhibit DNA-dependent synthesis of RNA in many systems, drastically inhibits puffs as well as the synthesis of certain proteins and RNA, regardless of the way in which it is administered (Beerman, 1966).

It is difficult to interpret and correlate all the different results given in the foregoing. However, a few facts stand out clearly and may be given in summary. There is little doubt that major changes in postembryonic development are associated with the appearance of specific puffing patterns in the chromosomes and these puffs reflect specific genomic activity of the cells This is proved by the abundance of RNA in the puffs as contrasted with the inactive bands. It is, however, not clear whether puff formation is the prerequisite or it succeeds RNA synthesis. In his autoradiographic studies, Pelling (1964) noted that only a small fraction of the larvae of *Chironomus tentans* injected with uridine showed any label, although puffs were present in all, so he concluded that puffs precede synthesis. On the other hand, the suppression of puffing activity by treatment with enzymes which inhibit the synthesis of RNA and proteins leads Clever (1967) to the inference that puff formation succeeds RNA synthesis.

In insects, it is proved beyond doubt that ecdysone causes a specific kind of puffing activity. Injection of pure ecdysone and ligature experiments demonstrate this conclusively. These results have also been confirmed by transplantation and *in vitro* cultivation of salivary glands of *Acricotopus lucidus*. By culturing the glands together with the brain and ring gland of *Calliphora erythrocephala* it was possible to trace back certain changes in the puffing pattern to those cells which are known to secrete ecdysone (Panitz, 1964). Further it has been observed that the size of the puffs depends upon the quantity of ecdysone in the environment. Still it is uncertain how exactly ecdysone acts. Kroeger believes that it brings about a change in the permeability of the cell wall and thereby a difference in the K^+/Na^+ ratio in the intracellular environment of the cell. The problem is further complicated by the production of puffs by certain ions, toxins etc., which are not accompanied by moulting. Thus one might describe these as inactive puffs in contrast to the active puffs associated with moulting. It might therefore, be useful to think of chromosomal puffs associated with developmental changes not as related to these changes alone or as cause and effect, but to view the entire gamut of activities represented by these changes as being controlled by factors which regulate the entire developmental process at a particular stage and the behaviour of the cells. Substances like ecdysone could be responsible for activating those factors, which may very well be certain genes.

So far ecdysone still remains the only substance definitely known to be normally involved in the puffing control in insects (Clever, 1967). As regards the juvenile hormone, no comparable study has been made yet. Kroeger (1963) had performed some initial experiments involving transplantation of corpora

allata, but no work on the direct effect of the hormone itself is available. This has been due largely to the failure of the workers generally to demonstrate any effect of the juvenile hormone recovered from Lepidoptera on higher Diptera (Kroegar and Lezzi, 1966). Very recently, however, it has been possible to produce dramatic effect of juvenile hormone on dipteran metamorphosis in the form of pupal-adult intermediates (Srivastava and Gilbert, 1968). A wide range of juvenile hormone mimics have also been shown to affect metamorphosis of *Sarcophaga* (Srivastava and Gilbert, 1969). Clear effect of juveniie hormone has also been noted in *Drosophila* in which apterous sterile strains can be made to produce yolky eggs under its influence (Srivastava, unpublished observations). These observations on the susceptibility of flies, particularly *Drosophila*, to treatment with juvenile hormone opens a new area of investigation in the field of chromosomal changes connected with metamorphosis. Until such investigations are made we have to remain content with some indirect observations and speculations.

Firstly, since juvenile hormone acts to modify the course of development initiated by ecdysone, it may be assumed that it has the same site of action as ecdysone, and that it affects chromosomes and influences synthesis. It also seems probable that the secretion of the moulting hormone and simultaneous withdrawal of the juvenile hormone leads to an altered chromosomal metabolism. Also it has been shown that puffing pattern during larval and pupal moults differs considerably in their secondary but not the primary sets, hence it may be regarded that the juvenile hormone intervenes in an unknown fashion with the activity of the primary puffs. Finally Becker (1962) in *Drosophila* and Kroeger (1963) in *Chironomus* noted that wounding caused blocking and reversal of the puffing pattern normally induced by ecdysone and the latter worker believes that juvenile hormone acts similarly. He also noted that when salivary glands of the third instar larvae of *Chironomus* are implanted in the prepupae, there is a reversal of the puffing pattern and thought that this gives an indication of the manner of action of the juvenile hormone. Whether juvenile hormone causes a depression in the activity of certain genes or alters the course of their function, initiated under the influence of ecdysone, it certainly provides a fascinating material to study with and offers great promise to the molecular biologist.

Another area of investigation in insect endocrinology in which some unexpected finding have been made involves a search for hormonally active substances in organisms other than insects and particularly in plants. While isolating and analysing the juvenilising extract from the mealworm *Tenebrio molitor*, Schmialek in 1961 came to the conclusion that the extract contains farnesol which is also a component of the essential oils of certain plants. When he tried farnesol experimentally on insects, he found that it possesses distinct juvenile hormone activity although pure insect juvenile hormone is about a million times stronger than it. Later it was discovered that certain chemical manipulations like chlorination or introduction of a methyl group in farnesol considerably enhance its activity. Four years later in 1965, Slama and Williams discovered that the American newspaper and other papers contain a factor which greatly mimics juvenile hormone in respect of its activity on insects. They called it the "paper factor" and noted that it was highly specific to bugs of the family Pyrrhocoridae on which topical applications of as small an amount as 0·001 μ gm produces dramatic effect on metamorphosis. (Slama and Williams, 1966). The mimetic substance, now known as juvabione, has been found to occur in wood pulp of the balsam fir, *Abies balsamea* from which most of the American paper is manufactured, and has been chemically identified as todomatuic acid methyl ester (Bowers *et al*, 1966). Surprisingly, it was later found that the pure extract is somewhat less active than the paper extract and

it is believed that during the process of paper manufacture, it undergoes some chemical change which enhances the hormonal activity of the compound (Staal, 1967). At the moment several laboratories all over the world are engaged in testing a variety of conifers and other plants for juvenile hormone mimetic substances.

There have been more startling discoveries regarding substances with moulting hormone activity in plants, all in the last two or three years. It has been mentioned that chemical analysis of the insect moulting hormone has revealed two substances named α ecdysone and β ecdysone respectively. The latter has also been called crustecdysone because it occurs in the Crustacea and ecdysterone on account of its chemical nature. Nakanishi and his collaborators (1966) were the first to report the occurrence of a significant quantity of the moulting hormone substance in the evergreen plant *Podocarpus nakaii* (Taxaceae). When the substance was analysed it was found to contain four components which were named ponasterone A, B, C, and D respectively, all believed to be closely similar to the authentic α and β ecdysones, and the mixture as such was found to be much more potent than either α or β ecdysone in respect to hormonal activity on insects (Kobayashi *et al*, 1967). From the roots of a weed *Achyranthes faurei* (Amaranthaceae) also Takemoto *et al* (1967*a*) isolated two hormonally active substances, inokosterone and isoinokesterone, both resembling ecdysone in chemical structure and property. The hormones were found active on *Musca* and *Bombyx*, isoinokosterone being more powerful than inokosterone (Kobayashi *et al*, 1967*b*). Likewise, Jizba *et al* (1967) extracted active β ecdysone from the rhizome of the fern *Polypodium vulgare*, Rimpler and Shulz (1967) from the leaves and roots of *Vitex megapotamica*, Hoffmeister *et al* (1967) from the leaves of several species of *Taxus* and Takemoto *et al* from *Cyathula capitata* (Amaranthaceae).

The quantities of the hormones recovered from the different plant sources have been of an astonishingly high order. Nakanishi (1966) and Takomoto *et al* (1967*a*) respectively recovered 0·05% and 0·06% of the hormone from the dry weights of the leaves and roots of their respective plants and W. J. Van der Burg of Netherlands succeeded in recovering 10 grs. of pure β ecdysone from 45 kg of dry leaves of *Taxus buccata*. If we take into account the yield of ecdysone from one of the richest insect sources known *i.e. Bombyx* pupae, that is 70 mg. from 1000 kg of pupae, one would be naturally surprised to note that the same activity would be available from only 70 grams of dry *Taxus* leaves (Staal, 1967). *Polypodium vulgare* is equally rich; its rhizome yields 1% of its dry weight of hormone. It would thus be seen that although ecdysone has not been found in plants (Staal, 1967), β ecdysone (crustecdysone), a minor component of the natural insect hormone, but the more powerful of the two, occurs in a large number of plants in large quantities.

While discussing this problem, one cannot lose sight of another intriguing fact that extracts from several groups of animals as Hydrozoa, Anthozoa Nimertinea, Ectoprocta, Polecypoda, Gastropoda, Polychaeta, Oligochaeta, Malacostraca, Arachnida, Holothuroidea and Balanoglossida, besides mammalian adrenals and certain bacteria have also been found to possess juvenile hormone activity (Schneiderman, Gilbert and Weinstein, 1960). Perhaps as Schneiderman *et al* have suggested earlier (1960), the occurrence of a hormonal substance in such a vast spectrum of living beings—bacteria, plants and animals—demonstrates that the development of humoral mechanisms involves not so much the evolution of specific hormones, but rather the evolution of mechanisms of exploitation of the existing chemicals in the target cells which acquire a sensitivity to specific

PRESIDENTIAL ADDRESS

Mycology in India

By

R. K. SAKSENA, M.Sc. (B. H. U.), Dr. ès Scs. (Sorbonne), F.N.A.Sc., F.N.I.

Retired Professor of Botany, University of Allahabad, Allahabad.

LADIES AND GENTLEMEN,

I am thankful to the members of the National Academy of Sciences for the honour they have done me by electing me their President for the year 1968.

Though some time has passed when I retired from active scientific pursuits yet I try to keep contacts with my students and younger colleagues. Naturally, I am delighted at their achievements and revelations of new facts but sometimes I feel sorry also to see some hasty publications. Since in this audience are scientists of different desciplines, I shall try to be as simple in my presentation as possible.

For many years I had been interested in a group of organisms called fungi which are claimed by both botanists and zoologists as belonging to their domain. Some people have even begun to think that they belong to a kingdom of their own. The common moulds that we often come across on spoiled or decomposing organic matter such as food stuffs, fruits and vegetables, pickles, the mushrooms that are curiosities of the children, some of them being really delicious and others deadly poisonous, and the wood destroying bracket-like organisms, are all fungi. Like us they also do not contain the green colouring matter (chlorophyll) hence they are also unable to manufacture their own food. But they differ in their mode of nutrition in that they digest the food first and then suck it in their body, while we take in the undigested food, whatever is more palatable, and then digest it later as much as we can inside our body. Possibly we would have done better if we could do the same as fungi do because then there would have been no question of constipation, a condition which attracts other diseases.

These organisms reproduce both asexually as well as sexually. Some of them have well developed reproductive organs while others, believed to be more advanced, have retained only essential features of all sexual processes, *viz.*, the fusion of two compatible nuclei and subsequent meiosis of the diploid nucleus.

The fungi were once looked down by man as obnoxious agents of disease and decay but now they have acquired a place of respect and admiration even in the eyes of the lay man. Since the dawn of history fungi have been decomposing, along with their partners the bacteria, the huge amount of organic waste that is thrown out from every house every day. Had they not being doing so, there would have been left no proper place for us to live by now.

Yeasts, the smallest of the fungi, have been fermenting sugary solutions to produce alcohol since time immemorial. They now serve as a useful source of proteins and vitamins for the starving millions of the world. Also many of the higher fungi produce their fruit bodies large and delicious enough to serve as a source of food, *e.g.*, morels (Morchellas), Clavarias, truffles (Tubers), etc. In foreign countries some of these are being grown and cultivated on a large scale just as other vegetables. However, few of these mushrooms contain dangerous poisons and are known to produce hallusinogenic substances which produce ecstatic effects in men. These hallusinogenic principles have been isolated and they are being used in experiments to study certain mental illnesses. Fungi are being used in processing of food, for example, *Penicillium camemberti* for Camembert cheese, and *Penicillium roqueforti* for Roquefort cheese. The role of fungi in medicine is not hidden even from the common man. He can never repay the debt which he owes

number of the human race from death and disease during war and peace. Even those who might not have taken a dose of penicillin yet they know the wonderful curative properties of this drug which has produced a revolution in the healing arts. Also, ergot, a drug long in use for obstetric purposes to induce uterine contractions in cases of delayed child birth is of fungus (*Claviceps purpurea*) origin. Fungi are now well recognized as capable of inducing such chemical transformations which man with all his ingenuity finds difficult to bring about. Synthesis of steroides (organic compounds produced by endocrine glands—testes, ovaries and placenta of pregnancy) is now possible with the help of a number of microorganisms particularly fungi. This has resulted into an entirely new branch of chemistry. Some of the fungi have wonderful capacity to convert carbohydrates into useful acids. Citric acid which is utilized in enormous quantities in all advanced countries of the world is mostly produced by fermentation, brought about by a strain of a black mould, *Aspergillus niger*.

Not only the fungi are being utilized for food and industry but they are serving as important tools by cytologists, geneticists and biochemists to reveal the intricate details of their life history, inheritance of characters, and to attack biochemical problems which are not so easy to tackle in other microbial, plant and animal systems. *Neurospora* is one such fungus which has been used extensively by geneticists because of its relatively simple nutrition, a short generation time and self sterility which permits the mating of control crosses.

Mycology, the science of fungi, began in India with stray collections of fungi by foreigners and later their identification and studies in foreign laboratories. Hooker and Thompson made an intensive collection of the mushrooms (Agarics) from the Eastern Himalayas and these were described by Barclay. Large number of fungi from Bengal and Burma were collected by Kurz and these were studied and reported by Currey. Later D. D. Cunningham from 1871 to 1896 and Barclay from 1889–1892 investigated a number of fungi in India belonging to the orders Mucorales, Ustilaginales and Uredinales (rusts). One of the first Indians to make a systematic study of fungi was K. R. Kirtikar who studied fleshy fungi of India during the later part of the 19th century. However, it was E. J. Butler whose arrival in India in the year 1905 as the Head of the Imperial and now Indian Agricultural Research Institute, New Delhi ushered a new era in the progress of Mycology and Plant Pathology in India. His book on plant pathogenic diseases in India is an exhaustive treatment and can not be replaced easily for years to come. During his 20 years stay in India and later after his departure in 1921 a number of trained mycologists and plant pathologists have been actively busy in various centres in India. During the early part of this century was at Allahabad, J. N. Mitter whose inspiring interest in general mycology specially taxonomy of fungi led to the establishment of a school of mycology and plant pathology in the Botany Department of the University of Allahabad. For a number of years myself and R. N. Tandon have run this school and have been responsible for establishing new traditions. Some notable contributions have been made in India concerning the morphology and taxonomy of fungi.

The slime molds (Myxomycetes), which have an amoeboid mass of protoplasm as their vegetative body, are claimed as falling in their domain by both the students of plants and animals. This group is of little economic importance but has interesting morphological features. In the past it has been studied by a number of workers and more recently by K. S. Thind. However, much more work has to be done on these organisms for their naked, multinucleate plasmodium offers great promise as an experimental material both for biochemists and biophysicists for studying stimulus response and protoplasmic syntheses. Their plasmodia can be chemically analysed without complication of nonliving cellulose walls.

The lowest group of the true fungi, the class Phycomycetes, has attracted the attention of many Indian mycologists. The chytrids, the lowest of the aquatic Phycomycetes have received very little attention in this country. The genera

Synchytrium and *Physoderma* have however been studied extensively (by M. J. Thirumalachar, B. T. Lingappa, and others). The most important genus of the Blastocladiales, *viz.*, *Allomyces* was established in India by E. J. Butler. It has been found to be of great interest to morphologists and geneticists subsequently. S. N. Das Gupta and Rachel John studied some members of this order as well as those of the Monoblepharidales and Lagenidiales. The Saprolegniales, a prominent aquatic group of the Phycomycetes, has been studied more intensively with regard to their physiology and cytology by myself and my associates (K. S. Bhargava, M. S. Murdia and others). Among the Peronosporales the genera that have been studied most in India are : *Albugo* (both life history and cytology of a few species by K. M. Safeeulla and M. J. Thirumalachar), *Pythium* and *Phytophthora* (mostly cytology and physiology by R. K. Saksena and his associates). The two important obligate parasites *Sclerospora* and *Peronospora* were studied by B.N. Uppal and K.S. Thind respectively. A new genus *Sclerophthora* combining the characters of *Phytophthora* and *Sclerospora* has been described by M.J. Thirumalachar, M. J. Narasimhan and C.G. Shaw in 1953.

The Mucorales, a group of mostly saprophytic and terrestrial fungi of the class Phycomycetes was very much neglected in India in the past. In 1953 S. B. Saksena described a remarkably new genus of this order, *Saksenaea*. Only a single species of this genus is known so far and inspite of best efforts no zygospores have been found. It is peculiar physiologically also as it does not sporulate under nutritional conditions under which most Mucorales do. A synthetic medium for growth and sporulation was not known till recently when Usha Baijal reported that a synthetic medium containing such carbon sources as arabinose, rhamnose, sorbose, galactose, lactose and citric acid, which support poor growth can support good or even excellent sporulation in this organism. Much work has been done in recent years on the Mucorales of India at Allahabad by my former student, B.S. Mehrotra and his associates. Several significant additions have been made to the order. Recently the *Blakeslea* and *Choanephora* controversy first started by S. Sinha (1940) seems to have been finally settled by B. S. Mehrotra and Baijal with the help of their new species *B. monospora*. They have justified the retention of the genus *Blakeslea*. The Mucorales are an interesting group of organisms both from the point of view of variety of morphological characters they exhibit and also because some of them are of industrial value also.

As compared to other groups of the fungi, the Ascomycetes have not received much attention of the Indian mycologists. The yeasts have been completely neglected except for some interesting cytological observations made by M. K. Subramaniam and his associates. To the powdery mildews have been added a genus *Astomella* by M. J. Thirumalachar and to Sphaeriales a genus *Bagcheea* by E. Muller and R. Menon in 1954. A number of the Pezizaceae and some of the Helotiaceae have been reported by K. S. Thind and his coworkers. Except for reporting a number of genera from different localities no significant contribution seems to have been made with respect to the Ascomycetes in India.

Among the 'lower' Basidiomycetes, the important plant pathogens, the smuts and the rusts have been extensively studied in India chiefly by B. B. Mundkur and M. J. Thirumalachar. A number of significant contributions describing a number of new genera and species have been made by them. K. D. Bagchee studied the rusts of Indian conifers and discovered the alternate hosts of several of them. Out of the 'higher' Basidiomycetes, the coral fungi (Clavariaceae) have been reported by K. S. Thind in a recent (1962) monograph. The Thelephoraceae have been studied by S. N. Banerji in 1935. Pioneering work on the polypores of India, particularly that of Bengal, has been done by S. R. Bose. Many of the higher Basidiomycetes such as that of the order Tremellales and Agaricales have still to be revealed.

Of the imperfect fungi (Deuteromycetes) only some of the genera have been studied more intensively. Of special mention are the works of T. S. Sadasivan on

Helminthosporium, of M. J. Thirumalachar and associates, on *Cercospora*. Recently R. N. Tandon and his associates have reported a number of imperfect fungi chiefly of Sphaeropsidales and Melanconiales from decaying fruits and as leaf spot fungi. He and his associates have done much work on the physiology of some fungi. The Aspergilli and Penicillia are being studied more intensively at Allahabad by B. S. Mehrotra and his students. Few new species have been reported. Many new habitats such as marine waters, and foam, sillage waters have yet to be explored for little known or not yet reported imperfect fungi.

That mycology is a dynamic descipline, playing a substantial role in the development of biological concepts and theories in development of agriculture and medicine, is well recognized. In recent years a large number of new fields of investigation in mycology have grown up. In the field of taxonomy and morphology of fungi a lot more has to be known inspite of the fact that approximately 23,400 new taxa have appeared in the last decade. It has been estimated that it will take nearly 50-75 years to reveal the total number and variety of fungi in the world Inspite of intensive activity in certain groups of fungi in India many more are still to be revealed. Though there has been an increase in the number of mycologists in India yet this increase has been much less in number as compared to many advanced countries of the world. Taxonomic mycology is gaining ground inspite of general criticism of morphological work, for on the correct identification of the organism depends the success of a fermentation industry and the success of a plant pathologist. To facilitate identification of some difficult groups of micro-organisms, mycologists or microbiologists are now resorting to neumerical taxonomy and are taking the help of computors. In India we have yet to start such intensive taxonomic studies.

The role of a mycologist in several fermentation industries is yet to be realised to the full in India. We still have very few fermentation industries as compared to such countries as U. S. A., U. S. S. R., Japan, etc. The result is that we are still importing many of the products of fermentation by micro-organisms. To quote an example, we are still importing huge quantities of citric acid. It is now time that a team of mycologists and biochemists should join hands to establish suitable fermentation industries to meet the growing needs of our country. The role of a mycologist in agriculture is in no way smaller than that of a plant pathologist for on the correct identification of the causal fungus depends the success of the plant pathologist. Medical mycology is still in its infancy in India. Some good work has been done under M. J. Thirumalachar at Pimpri, Poona, and H. K. Baruah at Gauhati. We have yet to have a group of good medical mycologists. The importance of fungi in causing disease in man and animals, is now well realised. Diseases by fungi though infrequent are equally dangerous and difficult to cure. Thus there is much scope for research in medical mycology in India for which medical doctors, mycologists and persons dealing with animal husbandry should work in close collaboration.

It is true that a morphological-taxonomic approach should form the basis of a study of fungi but we ought to include in courses of mycology the physiological, biochemical, genetical and economic aspects of fungi which have brought mycology to its present high status.

Before I close I would like to give a note of warning to our colleagues in mycology. In recent years there has been a tendency to merge mycology with microbiology and even in International Botanical Congress there is now no mycology Section. It has also been the general experience that in microbiological conferences there is a dominance of bacteriologists. Naturally under such circumstances the cause of mycology is bound to suffer and to safeguard it we ought to be more assertive.

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B-B-G-K-Y Hierarchy of Equations and Transport Properties of Dense Gases

By

P. L. BHATNAGAR

Indian Institute of Science, Bangalore-12

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PRESIDENTIAL ADDRESS

B-B-G-K-Y Hierarchy of Equations and Transport Properties of Dense Gases

By

P. L. BHATNAGAR

Indian Institute of Science, Bangalore-12

1. Boltzmann equation

The classical formulation of kinetic theory of gases depends on Maxwell-Boltzmann equation which is based on the following fundamental assumptions :

(*i*) The assembly of molecules can be adequately described by a single-particle distribution function $f(\vec{\xi}, \vec{r}, t)$ where $f(\vec{\xi}, \vec{r}, t)\, d\vec{\xi}\, d\vec{r}$ gives the number of particles whose molecular velocities lie in the velocity range $(\vec{\xi}, d\vec{\xi})$ and which lie in volume element $(\vec{r}, d\vec{r})$ at time t. The temporal behaviour of f is determined by the celebrated Boltzmann equation

$$\frac{\partial f}{\partial t} + \vec{\xi} \cdot \frac{\partial f}{\partial \vec{r}} + \frac{\vec{F}}{m} \cdot \frac{\partial f}{\partial \vec{\xi}} = \left(\frac{\delta f}{\delta t} \right)_{\text{collisions}} \tag{1·1}$$

where m is the mass of a particle, $\vec{F}$ is the force acting on a particle located at $\vec{r}$ at time t. We note that all the macroscopic quantities in which we are generally interested are given by the suitable moments of f :

$$\left.\begin{aligned}
&\text{Mass density : } m\,n\,(\vec{r}, t) = m \int f(\vec{\xi}, \vec{r}, t)\, d\vec{\xi} = \rho\,(\vec{r}, t) \\
&\text{Mean velocity : } \vec{u}\,(\vec{r}, t) = \frac{1}{n} \int \vec{\xi}\, f\, d\vec{\xi} \\
&\text{Mean temperature } T\text{ : } \tfrac{3}{2} k\, T\,(\vec{r}, t) = \frac{1}{n} \int (\vec{\xi} - \vec{u})^2 f\, d\vec{\xi} \\
&\text{Stress tensor : } P_{ij}\,(\vec{r}, t) = \frac{1}{n} \int (\xi_i - u_i)(\xi_j - u_j) f\, d\vec{\xi} \\
&\text{and} \\
&\text{Heat flux tensor : } S_{ijk}\,(\vec{r}, t) = \frac{1}{n} \int (\xi_i - u_i)(\xi_j - u_j)(\xi_k - u_k) f\, d\vec{\xi}
\end{aligned}\right\} \tag{1·2}$$

where $\int \ldots d\vec{\xi}$ denotes triple integration with respect to $d\xi_x$, $d\xi_y$, $d\xi_z$ between the limits $-\infty$ and ∞.

(*ii*) In the Boltzmann equation (1·1) the second and third terms denote respectively the streaming motion in the configuration and velocity spaces, while the term on the right hand side represents the effect of molecular interactions. Thus in writing (1·1) it is assumed that it is possible to separate out these three effects. This assumption amounts to saying that the particle collisions are rare and the average time spent by a particle in a collision with another particle is much smaller than the average time of free flight between the consecutive collisions or the average volume of the interparticle interaction is much smaller than the specific volume of the assembly. Thus if r_0 is the effective range of interparticle interaction force then $r_0^3 << \frac{1}{n}$ or $n << \frac{1}{r_0^3}$. Thus the Boltzmann formulation is valid for only sufficiently dilute gases.

(*iii*) To obtain explicit expression for the collision term, we must specify (*a*) the law of force of interaction, (*b*) mechanism of interaction and (*c*) the state of particles before and after the collision.

(*a*) Usually the force of interaction between two non-polar particles is taken to be derived from a central potential

$$\phi(\vec{r_1}, \vec{r_2}) = \phi(\,|\,\vec{r_1} - \vec{r_2}\,|\,) \equiv \phi_{12} \qquad (1\cdot3)$$

which depends entirely on the separation of the interacting particles and is independent of their orientation.

(*b*) As regards the mechanism of interaction, it is assumed that the collisions are strictly binary, *i.e.* when two particles are engaged in interaction with each other, no other particle interacts with them at the same time. Moreover, in most of the investigations only the elastic collisions are considered so that the inelastic processes, like dissociation, ionization and recombination, are ignored. Besides, the particles are taken as structureless point particles so that they can have only kinetic and potential energies.

(*c*) In the Maxwell-Boltzmann formulation, it is assumed that the pre-collisional positions and momenta of the colliding particles are uncorrelated so that the probability $P(\vec{\xi}_1, \vec{r}_1, \vec{\xi}_2, \vec{r}_2, t)$ that one of the colliding particles is at $\vec{r}_1$ and has velocity $\vec{\xi}_1$ and the other particle is at $\vec{r}_2$ and has velocity $\vec{\xi}_2$ at time t before a collision begins is given by the product of the individual events, namely by the product of probabilities $P(\vec{\xi}_1, \vec{r}_1, t)$ and $P(\vec{\xi}_2, \vec{r}_2, t)$. Similarly, the post-collisional positions and momenta of the colliding particles are also uncorrelated so that at time t after collision, the probability that the particle '1' is at $\vec{r}_1'$ and has velocity $\vec{\xi}_1'$ and the other particle is at $\vec{r}_2'$ and has velocity $\vec{\xi}_2'$ is given by

$$P(\vec{\xi}_1', \vec{r}_1', \vec{\xi}_2', \vec{r}_2', t) = P(\vec{\xi}_1', \vec{r}_1', t)\; P(\vec{\xi}_2', \vec{r}_2', t).$$

This assumption is called by the name of 'molecular chaos'.

(*d*) For the validity of binary collision hypothesis, it is necessary that the force of interaction is of such a short range that it may be more or less treated as an impulse. In view of this assumption, it is assumed that at the time of a collision the colliding particles are at locations $\vec{r}_1$ and $\vec{r}_2$ which do not differ much from

each other so that in writing the probability of collision of two particles, both the particles are taken at the same location. This assumption amounts to the neglect of the dimension of a particle in comparison with the range of the interparticle interaction force and the mean particle distance.

Under these assumption, it is easy to show that

$$\left(\frac{\delta f}{\delta t}\right)_{\text{collision}} = \int_{\vec{\xi}_1} \int_b \int_\varepsilon (f_1' f' - f_1 f)\, g b db d\varepsilon\, d\vec{\xi}_1, \tag{1·4}$$

where $f' = f(\vec{\xi}', \vec{r}, t), f_1' = f_1'(\vec{\xi}_1', \vec{r}, t)$, $\vec{\xi}, \vec{\xi}_1$ and $\vec{\xi}', \vec{\xi}_1'$ being the velocities of the colliding particles before and after the collision, $g = |\vec{\xi} - \vec{\xi}_1| = |\vec{\xi}' - \vec{\xi}_1'|$ is the magnitude of their relative velocities before and after the collision, b is the so-called impact parameter which denotes the nearest distance from the particle ($\vec{\xi}$) assumed to be at rest that the particle ($\vec{\xi}_1$) would have attained if the force of interaction would have been absent and ε is the angle which the plane of relative orbit makes with a fixed plane in space. It is clear that ε fixes the plane of relative trajectory of the interacting particles while b fixes the position of the relative trajectory of the particles in this plane (*vide* Fig. 1).

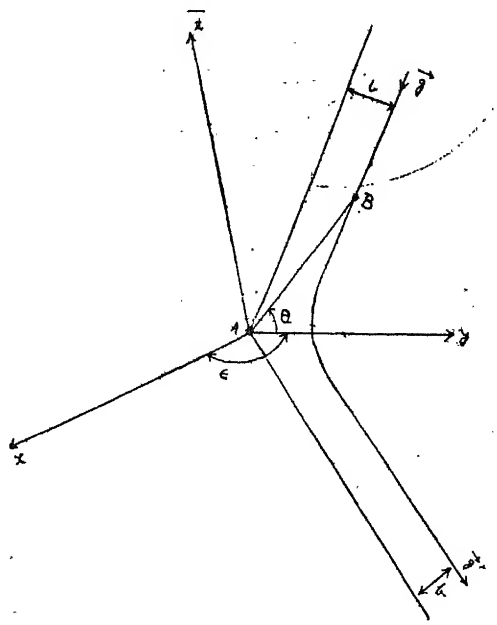

Fig. 1

2. Dense Gases

In a dense gas in which the range of interparticle interaction force is larger than the mean molecular distance, neither the size of the molecules can be neglected nor can the hypothesis of binary collisions strictly hold. Consequently, in a dense gas not many single binary collisions are completed and many triple and multiple collisions take place simultaneously.

In Figure 2, the dotted sphere C_1 is drawn with average interparticle distance centred at the molecule '1', while the spheres 1, 2, 3, ... denote the molecules, some lying within C_1 also. The bigger spheres S_1, S_2, S_3, ... are the interaction spheres associated with these molecules and are drawn with radius r_0 The intersection of S_1 with S_2, S_3, . . . indicates a multiple collision that the molecule '1' is having with molecules 2, 3, . . .

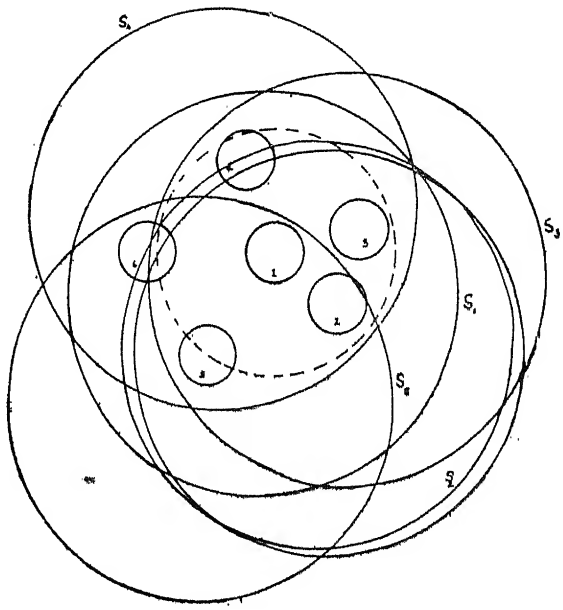

Fig. 2

Observationally, the spectrum of a dense gas shows considerable broadening. If collisions were binary and sharp, the spectrum lines should have been monochromatic. The line broadening suggests that collision lasts over a certain interval of time. During this interval, we cannot regard the interacting particles as two separate systems, but we must regard them as a single two-body system. This needs introduction of two-particle, three-particle and multi-particle distribution functions. In plasmas[2)], the situation is worse as the binary collision hypothesis is doubtful due to comparatively longer range of Coulomb interaction forces than the force of interaction between neutral particles. Thus in a plasma we expect a particle to undergo a collision with a large number of particles simultaneously. Thus for plasmas also we should not depend only on single particle distribution function and introduce multi-particle distributions.

Knowing that the evolution of transport properties is brought about by collisions, it is easy to see that in a dense neutral gas or in a high energy high density plasma, the transport properties can no longer be independent of density. We can understand this fact in the following manner. When the collisions are strictly binary, they take place quite independently of the other particles of the assembly and hence the transport properties become independent of density. On the other hand when the gas is dense the interaction volume becomes comparable

with the specific volume and the transport properties depend on density as well. Such a situation is met in systems like combustion engines operating at high temperatures and pressures. In these systems the transport properties such as viscosity and heat conductivity should show considerable deviation from their classical values.

In dilute gases, say in the density range of $10^{16} - 10^{18}$ particles per cubic centimeter and in pressure range $10^{-2} - 1$ atmosphere, the Maxwell-Boltzmann formulation is valid. For higher densities and pressures, we should take account of the multiple collisions through the introduction of two-particle, three-particle and higher order correlations. In the present address we shall concentrate on single-particle and pair-particle correlations only. This means that at present we are interested in moderately dense gases. We can easily find out the conditions under which this treatment is valid. First, for multiple collisions to be possible the volume of interaction sphere should be larger than the specific volume, *i.e.*

$$r_0^3 >> \frac{1}{n} \text{ or } n >> \frac{1}{r_0^3}.$$

Now let σ denote the effective diameter of a molecule so that $\pi\sigma^2$ is the effective cross-section and $\pi\sigma^2 r_0 n$ gives the number of particles interacting with a particle simultaneously (*vide* Fig. 3). If we want triple and multiple correlations to be weak so that the pair correlations are adequate to describe the assembly

$$\pi \sigma^2 r_0 n < 3 \qquad \text{or} \qquad n < \frac{1}{\sigma^2 r_0} \tag{2·1}$$

Thus in the present paper we are dealing with assemblies consisting of neutral molecules of one type for which

$$\frac{1}{r_0^3} << n < \frac{1}{\sigma^2 r_0}. \tag{2·2}$$

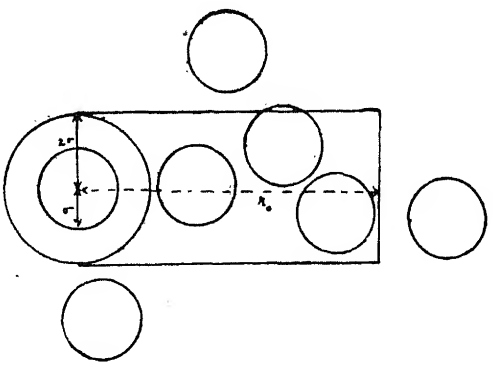

Fig. 3

3. Various approaches to the theory of dense gases

A number of workers have tried to study the dense gases starting from Enskog[3] himself. Enskog's theory is specifically applicable to a gas consisting of hard and rigid molecules so that it does not involve any interaction law between molecules. Since in a dense gas the size of the molecules cannot be neglected, he modified his theory for dilute gases to take account of this effect. In fact his theory corresponds to the hard sphere interaction potential defined by

$$\phi_{12} = \infty \quad , \; r < \sigma$$

$$= 0 \quad , \; r > \sigma$$

where σ is the diameter of the molecule regarded as rigid and hard and r is the separation distance between the interacting particles. Enskog's modified theory predicts the following expressions for the coefficient μ' of viscosity and thermal conductivity λ' :

$$\frac{\mu'}{\mu} = b\rho\left[\frac{1}{b\,\rho\,\chi} + \tfrac{4}{5} + 0{\cdot}7614\; b\,\rho\,\chi\right] \tag{3·1}$$

$$\mu = \frac{1{\cdot}016 \times 5}{16\sigma^2}\left(\frac{mkT}{\pi}\right)^{\frac{1}{2}}, \text{ viscosity for a dilute gas} \tag{3·2}$$

$$\frac{\lambda'}{\lambda} = b\rho\left[\frac{1}{b\,\rho\,\chi} + \tfrac{6}{5} + 0{\cdot}7574\; b\,\rho\,\chi\right] \tag{3.3}$$

$$\lambda = \frac{1{\cdot}02513 \times 75}{64\sigma^2}\left(\frac{k^3\,T}{\pi\,m}\right)^{\frac{1}{2}}, \tag{3·4}$$

thermal conductivity for a dilute gas

where

σ = diameter of a molecule

m = mass of a molecule

ρ = mass density of gas

T = temperature of gas in ^0K, $b = \dfrac{2\pi\sigma^3}{3m}$

and

$$\chi \simeq 1 + \tfrac{5}{8}\, b\rho + 0{\cdot}2869\; \rho^2\, b^2 + \ldots.$$

is a factor that takes account of the deviation from molecular chaos hypothesis and the finite size of the molecules. It is equal to unity for a dilute gas and increases with increasing density becoming infinite as it approaches the state in which the molecules are so closely packed that motion is impossible.

To fit the theory for hard sphere with observational data, he calculates the 'hard sphere diameter σ' of the molecule. If the fitting is done at low density, there is a large deviation at high densities. The curves μ'/ρ and λ'/ρ against ρ show minima in general. If the theory and observational data are fitted at this minima then there is appreciable discrepancy between the theoretical results and the experimental data at low density but shows good agreement at high densities. The latter procedure seems to be more reasonable since at high densities collisions with small impact parameters would be relatively more frequent than at low densities and therefore hard sphere model would be a better approximation at high densities. Moreover, the ratios μ'/μ and λ'/λ, no doubt depend on density of the gas, are independent of the temperature. We have recorded these facts to show the inadequacy of the hard sphere model.

Bogoliubov[4], Born and Green[5], Kirkwood[6] and Yvon[7] have independently established the equations for the pair correlations as well as the higher order correlations starting on somewhat different considerations but all of them ultimately arrive at the same equations. The equation determining the single-particle

distribution function contains two-particle distribution function, the equation determining the two-particle distribution functions contain three-particle distribution functions and so on as will be seen in the next section. Thus these equations are highly coupled. These authors differ in the method of breaking this coupling to get the closed form of equations. For example, Bogoliubov expands the distribution functions in terms of a parameter $\varepsilon = r_0^3/v$, where v is the specific volume. ε is small for classical fluids. The main difficulties about this expansion method are the following (*i*) the zeroth order equations, which we expect to be most dominant, are independent of the interaction term, (*ii*) it is not possible to establish the convergence and (*iii*) the equations are so complicated that so far nobody could study beyond the second order approximation. Kirkwood, on the other hand, breaks the coupling by postulating his famous superposition principle. He writes the potential energy of a system of three particles at $\vec{r}_1, \vec{r}_2, \vec{r}_3$ as

$$\phi(\vec{r}_1, \vec{r}_2, \vec{r}_3) = \phi(\vec{r}_1, \vec{r}_2) + \phi(\vec{r}_2, \vec{r}_3) + \phi(\vec{r}_3, \vec{r}_1) \tag{3·5}$$

which in terms of density distribution functions

$$n^{(h)}(\vec{r}_1, \vec{r}_2, \ldots, \vec{r}_h) = \int f^{(h)}(\vec{r}_1, \vec{p}_1, \vec{r}_2, \vec{p}_2, \ldots, \vec{r}_h, \vec{p}_h)\, d\vec{p}_1\, d\vec{p}_2 \ldots d\vec{p}_h \tag{3·6}$$

reduces to

$$n^{(3)}(\vec{r}_1, \vec{r}_2, \vec{r}_3) = \frac{1}{n^3} n^{(2)}(\vec{r}_1, \vec{r}_2)\; n^{(2)}(\vec{r}_2, \vec{r}_3)\, n^{(2)}(\vec{r}_3, \vec{r}_1) \tag{3·7}$$

where $n = n^{(1)}(\vec{r}_1) = n^{(1)}(\vec{r}_2) = n^{(1)}(\vec{r}_3)$ for the fluid in equilibrium. The meaning of this assumption, called the superposition approximation, may be understood as follows: The probability that any chosen three particles 1, 2, 3 out of the N particles in the system will be found in the configuration element $d\vec{r}_1\, d\vec{r}_2\, d\vec{r}_3$ about the configuration point $(\vec{r}_1, \vec{r}_2, \vec{r}_3)$ is $n^{(3)}(\vec{r}_1, \vec{r}_2, \vec{r}_3)$. The superposition assumption demands that this is proportional to the product of the probabilities that the pairs of molecules (1, 2), (2, 3), (3, 1) are at the configuration points $(\vec{r}_1, \vec{r}_2)$, $(\vec{r}_2, \vec{r}_3)$ and $(\vec{r}_3, \vec{r}_1)$ respectively. The factor $1/n^3$ is just the normalizing factor. The superposition approximation is certainly valid for a dilute gas but its validity for a dense gas is not fully justified. Moreover, the expression for the triple particle density distribution function in terms of the pair-particle distribution functions is highly non-linear and hence very complicated to work with. Consequently, this superposition assumption has been modified in a number of ways but all these modifications are all highly non-linear. However, recently Tchen[8] has proposed the following approximation which assumes the following quasi-linear expression for the ternary distribution function $f(1, 2, 3) = f(\vec{r}_1, \vec{p}_1, \vec{r}_2, \vec{p}_2, \vec{r}_3, \vec{p}_3, t)$ in terms of pair-particle distribution functions :

$$f(1, 2, 3) = f(1) f(2, 3) + f(2) f(3, 1) + f(3) f(1, 2) - 2f(1) f(2) f(3) \tag{3·8}$$

This expression gives the correct expression for $f(1, 2, 3)$ namely $f(1) f(2) f(3)$ when molecular hypothesis is accepted. Moreover, Tchen has shown that for weak interaction (small ϕ_{ij}), we can derive the above expression for $f(1, 2, 3)$ from B-B-G-K-Y hierarchy by means of expansion in powers of a small parameter $\lambda \propto v^{1/3}$.

4. B-B-G-K-Y Hierarchy

Let us consider $\mathcal{N}$ like neutral molecules in a volume V. Each molecule has mass m and at time t the i-th particle is at position $\vec{q_i}$ and has velocity $\vec{\xi_i}$ and momentum $\vec{p_i} = m\vec{\xi_i}$. We assume that the interaction between the i-th and the j-th particles is defined by the potential $\phi_{ij}(\,|\vec{q_i} - \vec{q_j}|\,)$.

Let us define the probability density

$$f^{(\mathcal{N})}(\vec{q_1}, \vec{p_1}, \vec{q_2}, \vec{p_2}, \ldots, \vec{q_{\mathcal{N}}}, \vec{p_{\mathcal{N}}}; t) \equiv f^{(\mathcal{N})}(\vec{q_i}, \vec{p_i}; t) \tag{4·1}$$

such that

$$f^{(\mathcal{N})}(\vec{q_i}, \vec{p_i}; t) \prod_{1 \leqslant i \leqslant \mathcal{N}} d\vec{q_i}\, d\vec{p_i} \tag{4·2}$$

gives the probability at time t that the coordinates of the i-th particle is in the range $(\vec{q_i}, \vec{p_i}, \vec{q_i} + d\vec{q_i}, \vec{p_i} + d\vec{p_i})$ $(i = 1, 2, \ldots, \mathcal{N})$

and

$$\int f^{(\mathcal{N})}(\vec{q_i}, \vec{p_i}; t) \prod_{1 \leqslant i \leqslant \mathcal{N}} d\vec{q_i}\, d\vec{p_i} = 1 \tag{4·3}$$

From the conservation of phase density

$$\frac{\partial f^{(\mathcal{N})}}{\partial t} + \sum_{1 \leqslant i \leqslant \mathcal{N}} \left(\frac{\partial f^{(\mathcal{N})}}{\partial \vec{q_i}} \cdot \dot{\vec{q_i}} + \frac{\partial f^{(\mathcal{N})}}{\partial \vec{p_i}} \cdot \dot{\vec{p_i}} \right) = 0 \tag{4·4}$$

which in view of the Hamiltonian equations

$$\dot{\vec{q_i}} = \frac{\partial H}{\partial \vec{p_i}}, \quad \dot{\vec{p_i}} = -\frac{\partial H}{\partial \vec{q_i}} \tag{4·5}$$

yields the celebrated Liouville equation

$$\frac{\partial f^{(\mathcal{N})}}{\partial t} = [\, H; f^{(\mathcal{N})} \,] \tag{4·6}$$

where

$$H = \sum_{1 \leqslant i \leqslant \mathcal{N}} \left\{ \frac{\vec{p_i}^2}{2m} + U_i(\vec{q_i}) \right\} + \sum\sum_{1 \leqslant i < j \leqslant \mathcal{N}} \phi_{ij} \tag{4·7}$$

is the Hamiltonian of the system and the symbol

$[\, H; f^{(\mathcal{N})} \,]$ stands for the Poisson bracket, so that

$$[\, H; f^{(\mathcal{N})} \,] = \sum_{1 \leqslant i \leqslant \mathcal{N}} \left(\frac{\partial H}{\partial \vec{q_i}} \cdot \frac{\partial f^{(\mathcal{N})}}{\partial \vec{p_i}} - \frac{\partial H}{\partial \vec{p_i}} \cdot \frac{\partial f^{(\mathcal{N})}}{\partial \vec{q_i}} \right) \tag{4·8}$$

We now define the s-particle distribution function

$$f^{(s)}(\vec{q}_1, \vec{p}_1, \vec{q}_2, \vec{p}_2, \ldots, \vec{q}_s, \vec{p}_s ; t), \qquad s = 1, 2, \ldots, \mathcal{N}$$

such that

$$\frac{1}{V^s} f^{(s)} \prod_{1 \leqslant i \leqslant s} d\vec{q}_i \, d\vec{p}_i =$$

$$\prod_{1 \leqslant i \leqslant s} d\vec{q}_i \, d\vec{p}_i \int f^{(\mathcal{N})} \prod_{s+1 \leqslant i \leqslant \mathcal{N}} d\vec{q}_i \, d\vec{p}_i \tag{4·9}$$

is the probability that the group of s-particles designated by the suffixes 1, 2, ... , s are in the dynamical state $(\vec{q}_i, \vec{p}_i, \vec{q}_i + d\vec{q}_i, \vec{p}_i + d\vec{p}_i)$, $i = 1, 2, \ldots, s$. We note the inclusion of the normalizing factor $\frac{1}{V^s}$.

We can readily obtain the equation satisfied by $f^{(s)}$ by multiplying the Liouville equation by $\prod_{s+1 \leqslant i \leqslant \mathcal{N}} d\vec{q}_i \, d\vec{p}_i$ and integrating over the entire phase space accessible to the assembly :

$$\frac{\partial f^{(s)}}{\partial t} = [\, H_s ; f^{(s)} \,] + \frac{\mathcal{N} - s}{V} \sum_{1 \leqslant i \leqslant s} \int [\, \phi_{i,s+1} ; f^{(s+1)} \,] \, d\vec{q}_{s+1} \, d\vec{p}_{s+1} \tag{4·10}$$

whre H_s is the s-particle Hamiltonian and $s = 1, 2 \ldots, \mathcal{N}$. It is easy to see that the first term on the right hand side of (4·10) represents the free-streaming of the group of s-particles under consideration while the second term represents the action of the remaining $\mathcal{N} - s$ particles on these s-particles.

As pointed out earlier the set of equations (4·10) is highly coupled as the equation for $f^{(s)}$ contains $f^{(s+1)}$ besides being integro-partial and nonlinear equations. We record below for ready reference the equation satisfied by $f^{(1)}$ (1) and $f^{(2)}(1, 2)$:

$$\frac{\partial f^{(1)}(1)}{\partial t} + \left(\frac{\partial H_1}{\partial \vec{p}_1} \cdot \frac{\partial}{\partial \vec{q}_1} - \frac{\partial H_1}{\partial \vec{q}_1} \cdot \frac{\partial}{\partial \vec{p}_1} \right) f^{(1)}(1)$$

$$= \frac{\mathcal{N} - 1}{V} \int \frac{\partial \phi_{12}}{\partial \vec{q}_1} \cdot \frac{\partial f^{(2)}(1,2)}{\partial \vec{p}_1} \, d\vec{q}_2 \, d\vec{p}_2 \tag{4·11}$$

and

$$\frac{\partial f^{(2)}(1,2)}{\partial t} + \left(\frac{\partial H_2}{\partial \vec{p}_1} \cdot \frac{\partial}{\partial \vec{q}_1} - \frac{\partial H_2}{\partial \vec{q}_1} \cdot \frac{\partial}{\partial \vec{p}_1} \right) f^{(2)}(1,2)$$

$$+ \left(\frac{\partial H_2}{\partial \vec{p}_2} \cdot \frac{\partial}{\partial \vec{q}_2} - \frac{\partial H_2}{\partial \vec{q}_2} \cdot \frac{\partial}{\partial \vec{p}_2} \right) f^{(2)}(1, 2)$$

$$= \frac{\mathcal{N} - 2}{V} \int \left\{ \frac{\partial \phi_{13}}{\partial \vec{q}_1} \cdot \frac{\partial}{\partial \vec{p}_1} + \frac{\partial \phi_{23}}{\partial \vec{q}_2} \cdot \frac{\partial}{\partial \vec{p}_2} \right\} f^{(3)}(1, 2, 3) \, d\vec{q}_3 \, d\vec{p}_3 \tag{4.12}$$

5. New Approach

In this section we shall discuss the work that we[9] have recently done. The aim of our investigation is to establish transport equations to determine the transport coefficients such as viscosity and heat conductivity. The earlier investigations, such as those of Bogoliubov and Tchen, provide just the formal solutions. Consequently we have adopted Grad's method[10] of expansion in terms of generalized Hermite polynomials to the solution of B-B-G-K-Y Hierarchy. We[11] have used earlier this method successfully in the determination of transport properties on the basis of Boltzmann equation with B-G-K model for collision integrals. Moreover, in order to decouple the hierarchy of equations we have adopted the Tchen's prescription which has been proved valid at least in the case of dilute gases.

For sake of ready reference we note that the generalized Hermite polynomials of order n are defined by the following relation :

$$H^{(n)}_{(i_1, i_2, \ldots, i_n)} = \frac{(-1)^n}{\omega} \frac{\partial}{\partial v_{i_1}} \frac{\partial}{\partial v_{i_2}} \cdots \frac{\partial}{\partial v_{i_n}} \omega \tag{5·1}$$

where

$$\omega = \frac{1}{(2\pi)^{3/2}} \exp \left[-\tfrac{1}{2} \sum_{1 \leqslant i \leqslant \mathcal{N}} v_i^2 \right. \tag{5·2}$$

is the Maxwellian distribution function in $\mathcal{N}$ dimensional space $(v_1, v_2, \ldots, v_{\mathcal{N}})$ These polynomials satisfy the following orthonormality relation

$$\left. \begin{aligned} \int \omega H^{(m)}(\vec{v}) H^{(n)}(\vec{v})\, \vec{dv} &= o, \text{ when } (n) \not\equiv (m) \\ &= \prod_{1 \leqslant i \leqslant \mathcal{N}} (m_i!), \text{ when } (n) \equiv (m). \end{aligned} \right] \tag{5·3}$$

For making a further progress we have to first obtain convenient expressions for the interaction integrals in (4·11) and (4·12). We write the integral on the right hand side of (4·11) as

$$\frac{\mathcal{N}-1}{V} \int (X f^{(2)})\, \vec{dq_2}\, \vec{dp_2} \tag{5·4}$$

where $Xf^{(2)}$ represents the rate of change of $f^{(2)}$ due to variation of $\vec{p_1}$ along the trajectory of the two particles during collision. If we denote the momenta of two colliding particles before and after collision by $\vec{p_1}, \vec{p_2}$ and $\vec{p_1}', \vec{p_2}'$ respectively and by $bdbde$ the differential collision cross-section for collision, then the change in $f^{(2)}$ due to collision will be given by

$$\begin{aligned} &\iint f^{(2)}(\vec{q_1}, \vec{p_1}', \vec{q_1}+\vec{b}, \vec{p_2}')\, g\, bdbde\, \vec{dp_1}' \\ &\quad - \iint f^{(2)}(\vec{q_1}, \vec{p_1}, \vec{q_1}-\vec{b}, \vec{p_2})\, g\, bdbde\, \vec{dp_2} \end{aligned} \tag{5·5}$$

so that the value of the above integral may be taken as

$$\frac{\mathcal{N}-1}{V} \iint \left[f^{(2)}(\vec{q_1}, \vec{p_1}', \vec{q_1}-\vec{b}, \vec{p_2}', t) - f^{(2)}(\vec{q_1}, \vec{p_1}, \vec{q_1}+\vec{b}, \vec{p_2}, t) \right] g_{12}\, b_{12}\, db_{12}\, d\varepsilon_{12}\, \vec{dp_2} \tag{5·6}$$

For short range forces of the type which operate between the neutral molecules, the main contribution to the integral will come from small values of the impact parameter b. Thus, if the limit of integration for b is small ($\cong r_0$) we can replace $\vec{q}_1 - \vec{b}$ and $\vec{q}_1 + \vec{b}$ by $\vec{q}_1$ itself without involving any appreciable error. We can thus replace the integrals on the right hand sides of (4·11) and (4·12) respectively by

$$\frac{N-1}{V} \int \left[f^{(2)} (\vec{q}_1, \vec{p}_1', \vec{q}_1, \vec{p}_2', t) - f^{(2)} (\vec{q}_1, \vec{p}_1, \vec{q}_1, \vec{p}_2, t) \right] g_{12}\, b_{12}\, db_{12}\, d\varepsilon_{12}\, d\vec{p}_2 \tag{5·7}$$

and

$$\frac{N-2}{V} \left[\int \left[f^{(3)} (\vec{q}_1, \vec{p}_1', \vec{q}_2, \vec{p}_2, \vec{q}_1, \vec{p}_3', t) - f^{(3)} (\vec{q}_1, \vec{p}_1, \vec{q}_2, \vec{p}_2, \vec{q}_1, \vec{p}_3, t) \right] g_{13}\, b_{13}\, db_{13}\, d\varepsilon_{13}\, d\vec{p}_3 \right.$$
$$\left. + \int \left[f^{(3)} (\vec{q}_1, \vec{p}_1, \vec{q}_2, \vec{p}_2', \vec{q}_2, \vec{p}_3', t) - f^{(3)} (\vec{q}_1, \vec{p}_1, \vec{q}_2, \vec{p}_2, \vec{q}_2, \vec{p}_3, t) \right] g_{23}\, b_{23}\, db_{23}\, d\varepsilon_{23}\, d\vec{p}_3 \right] \tag{5·8}$$

On substituting the expressions for $f^{(3)}$ in terms of $f^{(2)}$ and $f^{(1)}$ according to Tchen's prescription, the equations determining the single particle and pair-particle distribution functions become closed.

Before applying Grad's expansion method to (4·11) and (4·12) after replacing the interaction integrals by (5·7) and (5·8) we render our momenta and distribution functions dimensionless according to the following scheme :

$$\vec{P}_i = \frac{1}{m a_i} \vec{p}_i, \qquad a_i = \left[\frac{KT (\vec{q}_i, t)}{m} \right]^{\frac{1}{2}} \tag{5·9}$$

$$F_1 = (m a_1)^3 f^{(1)} (\vec{q}_1, \vec{p}_1 ; t)$$
$$F_{12} = (m^2 a_1 a_2)^3 f^{(2)} (\vec{q}_1, \vec{p}_1, \vec{q}_2, \vec{p}_2 ; t) \tag{5·10}$$
$$F_{123} = (m^3 a_1 a_2 a_3)^3 f^{(3)} (\vec{q}_1, \vec{p}_1, \vec{q}_2, \vec{p}_2, \vec{q}_3, \vec{p}_3 ; t)$$

$T (\vec{q}_i, t)$ being temperature at the location $\vec{q}_i$.

Following Grad we assume the following expansions for the single particle and pair particle distribution functions :

$$F_1 = \omega (\vec{P}_i) \sum_n A^{(n)} (\vec{q}_1, t)\ H^{(n)} (\vec{P}_1) \tag{5·11}$$

and

$$F_{12} = \omega (\vec{P}_1)\, \omega (\vec{P}_2) \sum_m \sum_n B^{(m,n)} (\vec{q}_1, \vec{q}_2, t)\, H^{(m)} (\vec{P}_1)\, H^{(n)} (\vec{P}_2) \tag{5·12}$$

where

$$\omega(P_i) = \frac{1}{(2\pi)^{3/2}} \exp\left(-\tfrac{1}{2}\vec{P_i}^2\right) \tag{5·13}$$

From the orthogonality relations for generalized Hermite Polynomials we immediately have

$$A^{(n)} = \frac{1}{X^{(n)}} \int H^{(n)}(\vec{P_1})\ F_1\, d\vec{P_1} \tag{5·14}$$

and

$$B^{(m,n)} = \frac{1}{X^{(m)}\ X^{(n)}} \iint H^{(m)}(\vec{P_1})\ H^{(n)}(\vec{P_2})\ F_{12}\, d\vec{P_1}\, d\vec{P_2} \tag{5·15}$$

where

$X^{(r)} = r_1!\, r_2!\, r_3!$, $(r) = (r_1, r_2, r_3)$ is the set of indices in the directions 1, 2, 3 in $H^{(n)}$ such that $r_1 + r_2 + r_3 = r$. It is evident from the relations (5·14) and (5·15) that the coefficients $A^{(n)}$ and $B^{(m,n)}$ are nothing but the linear combinations of the moments of distribution functions.

These non-dimensional distribution functions are determined by the following equations

$$\frac{\partial F_1}{\partial t} + a_1 \vec{P_1} \cdot \frac{\partial F_1}{\partial \vec{q_1}} - 3\left[\frac{\partial}{\partial t}(\log a_1) + a_1 \vec{P_1} \cdot \frac{\partial}{\partial \vec{q_1}}(\log a_1)\right] F_1$$

$$= \frac{N-1}{V} \iint [F'_{12} - F_{12}]\, G_{12}\, b_{12}\, db_{12}\, d\varepsilon_{12}\, d\vec{P_2} \tag{5·16}$$

and

$$\frac{\partial F_{12}}{\partial t} + \sum_{1 \leqslant i \leqslant 2} \left[a_i \vec{P_i} \cdot \frac{\partial F_{12}}{\partial \vec{q_i}} - \frac{1}{m a_i} \frac{\partial \phi_{12}}{\partial \vec{q_i}} \cdot \frac{\partial F_{12}}{\partial \vec{P_i}} \right.$$

$$\left. - 3\left\{\frac{\partial}{\partial t}(\log a_i) + a_i \vec{P_i} \cdot \frac{\partial}{\partial \vec{q_i}}(\log a_i)\right\} F_{12}\right]$$

$$= \frac{N-2}{V} \sum_{1 \leqslant i \leqslant 2} a_i (F_{123}' - F_{123})\, G_{i3}\, b_{i3}\, db_{i3}\, d\varepsilon_{i3}\, d\vec{P_3} \tag{5·17}$$

where when $i = 1$

$$F_{123}' - F_{123} = F_{123}'(\vec{q_1}, \vec{P_1}', \vec{q_2}, \vec{P_2}, \vec{q_1}, \vec{P_3}'\ ; t) - F_{123}(\vec{q_1}, \vec{P_1}, \vec{q_2}, \vec{P_2}, \vec{q_1}, \vec{P_3}\ ; t) \tag{5·18}$$

and when $i = 2$

$$F_{123}' - F_{123} = F_{123}'(\vec{q_1}, \vec{P_1}, \vec{q_2}, \vec{P_2}', \vec{q_2}, \vec{P_3}'\ ; t) - F_{123}(\vec{q_1}, \vec{P_1}, \vec{q_2}, \vec{P_2}, \vec{q_2}, \vec{P_3}\ ; t) \tag{5·19}$$

with Tchen's relations

$$F_{123} = F_1 F_{23} + F_2 F_{31} + F_3 F_{12} - 2 F_1 F_2 F_3 \tag{5·20}$$

Multiplying (5·16) by $H^{(r)}(\vec{P_1})$ and integrating with respect to $\vec{P_1}$ we get the equations for $A^{(r)}$. Similarly we get the equation for $B^{(r,s)}$ by integrating (5·17) with respect to $\vec{P_1}$ and $\vec{P_2}$ after multiplying by $H^{(r)}(\vec{P_1})\ H^{s}(\vec{P_2})$. We are not recording these equations on account of their size. Instead we give below the expressions which we obtain for viscosity and heat conductivity.

6. Transport properties

In most of the problems concerning fluids, the thirteen macroscopic variables, namely density, mean velocity, stress tensor, heat flux vector adequately describe the phenomenon and higher order moments have a negligible effect. The skewness and deformation brought about in distribution functions by using these variables adequately take account of the macroscopic situations in the neighbourhood of thermodynamic equilibrium. Consequently we truncate the infinite expansions (5·11) and (5·12) for F_1 and F_{12} respecting at $n = 3$ and $m + n = 3$. Similarly we truncate the collision terms in the equations for $A^{(r)}$ and $C^{(r,s)}$ at $l + n = 3$. We thus get a consistent set of equations for the moments upto third order.

(a) *Viscosity*

To obtain the expression for viscosity we consider a simple two-dimensional Couette flow in the absence of external forces and concentrate on the dependence of the stress component P_{12} on velocity derivatives. We thus get

$$P_{12} = -\bar{\eta}\left[\tfrac{1}{2}\left(\frac{\partial u_1}{\partial x_2} + \frac{\partial u_2}{\partial x_1}\right)\right]$$

where

$$\bar{\eta}/\eta = \left[1 + \frac{1}{A}\left\{\left(<0,0/2> + <0,0/2>\right)^2 (1/a^2)\right.\right.$$
$$\left.\left. - \{<1,1/2> + <1,1/2>\}\ \frac{n}{a^4} + \{<2,0/2> + <0,2/2>\}^2 \frac{n^2}{a^2}\right\}\right]^{-1} \qquad (6\cdot2)$$

$$A = <2,0/2> + <0,2/2> \qquad (6\cdot3)$$

$$\eta = \frac{2\,a\,n\,V\,k}{N-1}\,\frac{1}{A} \qquad (6\cdot4)$$

is the viscosity in the absence of correlations

and

$$<1, n/r> = \iiint \omega(\vec{P_1})\ \omega(\vec{P_2})\left[H^{(1)}(\vec{P_1}')\ H^{(n)}(\vec{P_2}')\right.$$
$$\left. - H^{(1)}(\vec{P_1})\ H^{(n)}(\vec{P_2})\right] H^{(r)}(\vec{P_1})\ G_{12}\ b_{12}\ db_{12}\ d\varepsilon_{12}\ d\vec{P_2}\ d\vec{P_1} \qquad (6\cdot5)$$

which can be integrated after substituting for the momenta $\vec{P_1}'$, $\vec{P_2}'$ after collision of the colliding particles and specifying the law of interaction force.

This expression for $\bar{\eta}/\eta$, unlike Enskog's expression, depends on temperature through the local sound speed a. From (6·2), it is clear that the terms within the curly brackets can be interpreted to represent the contribution of the shielding effect of the increasing density over and above the contribution of the unshielded binary collisions. Moreover, when the temperature T is increased keeping the

particle density n fixed, the contribution of the correlations becomes smaller and smaller. This is due to the increase in the mean molecular motion which results in the decrease of the shielding effect.

(*b*) *Heat conductivity*

To obtain the expression for heat conductivity, we consider one-dimensional heat flow problem and concentrate on the dependence of the heat flux on the temperature gradient. Thus we get

$$S_1 = -\bar{K}\frac{\partial T}{\partial x_1} \tag{6·6}$$

$$\bar{K}/K = \Big[\, 1 - \frac{1}{B}\Big\{ \frac{n}{a^2}\,(< 1, 0/3, > + < 0, 1/3 >)^2 + \frac{n}{a^4}\,(< 0, 1/1 > + < 1, 0/1 >)^2 - \frac{n^2}{a^4}\,(< 1, 2/3 > + < 2, 1/3 >)^2 - \frac{n^2}{a^6}\,(< 1, 2/1 > + < 2, 1/1 >)^2 \Big\} \Big]^{-1} \tag{6·7}$$

where

$$B = < 3, 0/3 >''' + < 0, 3/3 >''' + < 3, 0/3 >'' + < 0, 3/3 >'' \tag{6·8}$$

$$< l, n/3 >'''_s = < l, n/3 > + 3a_1^2 < l, n/1 > \tag{6·9}$$

$$< l, n/3 >'' = < l, n/3 > + a_1^2 < l, n/1 > \tag{6·10}$$

and

$$K = \frac{15\, a\, n\, V k}{2(N-1)}\,\frac{1}{B} \tag{6·11}$$

is the heat conductivity in the absence of correlations.

Here again the terms within the curly brackets represent the contribution of shielding effect of increasing density over and above the contribution of the unshielded binary interactions and these terms depend on density as well as on the temperature. When the temperature is increased, keeping the particle density fixed, the effect of correlations decreases.

We have carried out the numerical work for the case of intermolecular forces inversely proportional to the power of separation of the molecules with potential $\phi_{12} = dr^{-s}$, $s = 5, 7, 19, 27$ and the Lenard-Jones[6,12] potential

$$\phi_{12} = 4\varepsilon\left[\,(\frac{\sigma}{r})^{12} - (\frac{\sigma}{r})^{6}\,\right]$$

where σ is the value of r where $\phi_{12} = 0$, ε is the maximum energy of attraction (or the depth of potential well) which occurs at $r = 2^{1/6}\,\sigma$. The following table gives the observational values of the parameters σ and ε for some simple gases :

gas	$\sigma\, A^\circ$	$\varepsilon/k\ ^\circ K$
Helium	2·556	10·22
Neon	2·82	36·3
Argon	3·45	119·3

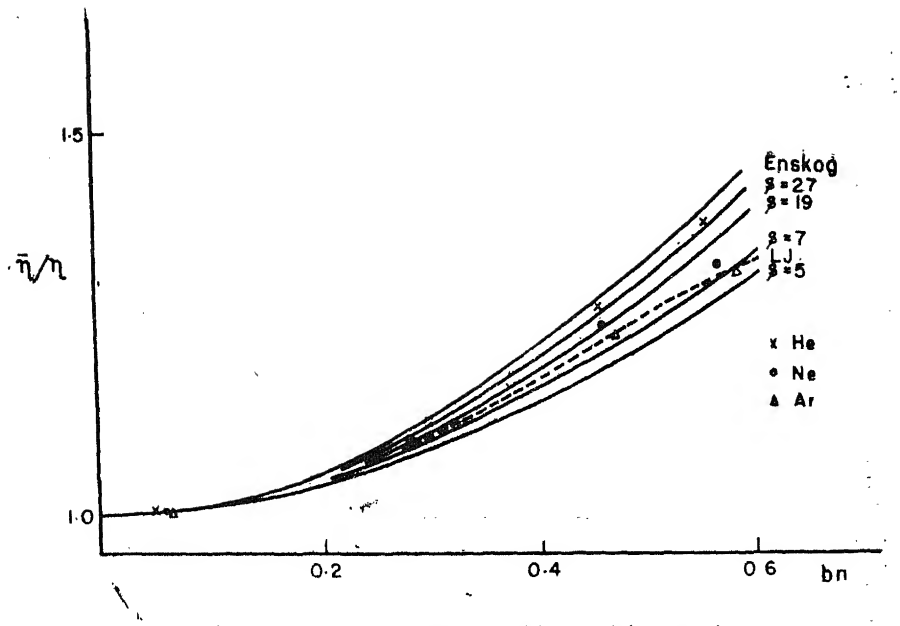

Fig.4 Variation of viscosity with particle density

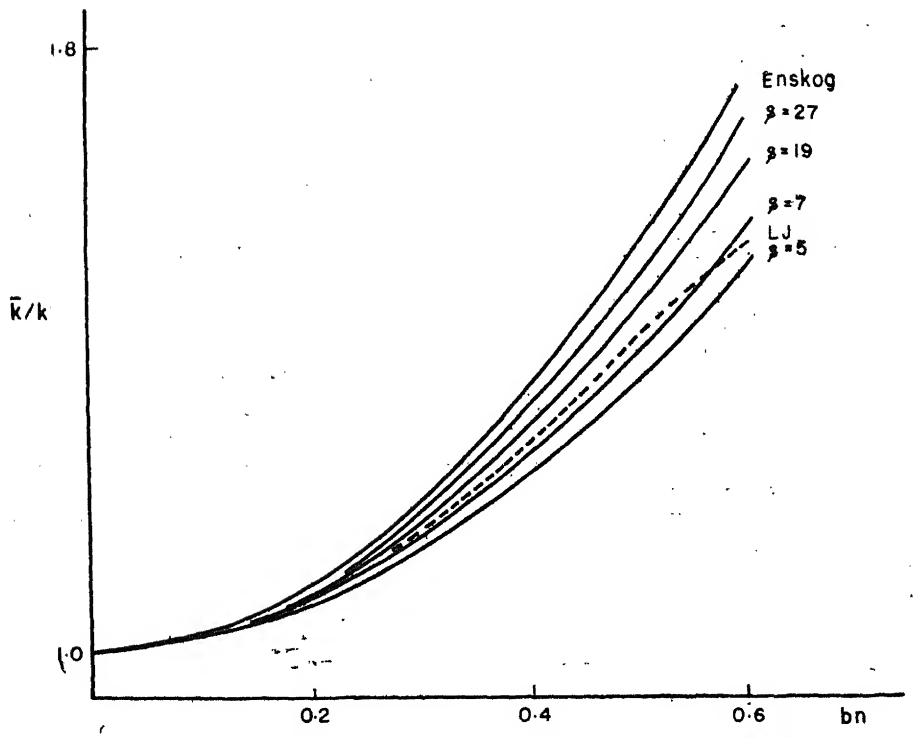

Fig.5 Variation of thermal conductivity with particle density

Fig. 4 plots η/η against bn where b is the specific volume. As the exponent $s \to \infty$, our curves gradually approach the Enskog curve. At small densities all power laws give almost the same result, but as the density increases, the power law curves vary much less rapidly than the Enskog curve.

Fig. 5 plots $\bar{\lambda}/K$ against bn. The trend of the results on heat conductivity is the same as for the viscosity. However, numerically speaking, the heat conductivity varies little more than the viscosity, thereby indicating an increase in Prandtl number.

We have also plotted in these figures the experimental results for helium, neon and argon after properly scaling these results. We find these experimental results in better agreement with our results than Enskog's results for hard rigid spheres specially at higher densities.

From comparison with the experimental results, we can draw valid conclusions regarding the postulated molecular interaction potentials. For instance, *He* is found to follow the trend shown by Lennard-Jones potential, whereas for *Ar* and *Ne* central potential with $s = 9$ would be a better fit. One final remark should be worth noting. Inspite of the weaker quasilinearity assumption of Tchen for multiple correlation we have got good results owing to the fact that transport processes are near equilibrium phenomena, hence quasilinearity adequately accounts for these. However, for situation far removed from equilibrium state, like beam interactions or the presence of radiation field or for strongly bound plasmas of reaction chamber, one has to use stronger approximations like Kirkwood superposition principle in order to preserve the inherent non-Markovian nature of the system. This limits the applicability of the present analysis.

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THE

National Academy of Sciences, India

THIRTY-EIGHTH ANNUAL SESSION

RANCHI, March 17-19, 1969

SECRETARIES REPORT

By

PROF. M. D. L. SRIVASTAVA, D.Sc., F.N.A.Sc.

NATIONAL ACADEMY OF SCIENCES
LAJPATRAI ROAD
ALLAHABAD
1969

SECRETARIES' REPORT

By

PROF. M. D. L. SRIVASTAVA, D.Sc., F.N.A.Sc.,

We have pleasure in submitting the following report on the working of the Academy during the period 1st January to 31st December, 1968.

MEMBERS

The Academy has on its rolls 654 members in good standing, of whom 159 are Fellows.

The following have been elected and enrolled during the year and we take this opportunity of welcoming them as members of the Academy.

1. Shri A. D. Adoni, M.Sc., Asst. Professor, Department of Botany, University of Saugar, Sagar (M. P.).
2. Miss Indra Agrawal, M.Sc., B-2 Shiv Road, Ratanada, Jodhpur.
3. Shri L. K. Bhagchandani, M.Sc., Department of Maths., University of Jodhpur, Jodhpur.
4. Shri J. S. Bisht, M.Sc., Lecturer in Zoology, Th. D. S. B. Govt. College, Nainital.
5. Dr. R. P. Bose, M.Sc , Ph.D., Gardener Curactor, Botanical Survey of India, 10 Chatham Lines, Allahabad.
6. Dr. Devinder Singh Chahal, M.Sc., Ph.D., Astt. Prof. of Plant Pathology, Department of Botany and Plant Pathology, Punjab Agricultural University, Ludhiana.
7. Dr. J. C. Chander, M.Sc., Dept. of Zoology, Meerut College, Meerut.
8. Dr. B. Choudhuri, M.Sc., Ph.D., Research Scholar, C/o Dr. R. R. Giri, Deptt. of Maths., Jadavpur University, Calcutta-32.
9. (Km.) G. R. Claudius, M.Sc., Research Scholar, Deptt. of Botany, University of Saugar, Sagar (M. P.).
10. Shri M. C. Durgapal, M.Sc., Lecturer, Deptt. of Physics, University of Jodhpur, Jodhpur.
11. Dr. M. S. Dubale, M.Sc., Ph.D., Prof. and Head of the Department of Zoology, University School of Sciences, Gujarat University, Navrangpura, Ahmedabad-9.
12. Dr. R. K. Dixit, M.Sc., D.Phil., Astt. Prof. of Zoology, D. S. B. Govt. College, Nainital.
13. Shri Sabhakar Ganguly, M.A., Lecturer, Deptt. of Mathematics, Barasat Govt. College, P.O. Barasat, Distt. Parganas.
14. Dr. R. M. Grade, M.Sc., Ph.D., Reader in Maths , Deptt. of Maths., Govt. Engineering College, Jabalpur.
15. Dr. R. B. Ghosh, M.Sc., D.Phil., Botanist, Indian Botanic Graden, Sibpore, Howrah (W. B.).
16. Dr. P. K. Grover, M.Sc., Ph.D., Associate Prof. of Plant Pathology, Panjab Agricultural University, Ludhiana.
17. Shri Henry Wadsworth Gould, M.A., Associate Prof. of Maths., Deptt. of Maths., West Virginia University, Morgantown, W.V. 26506, U. S. A.
18. Dr. Jin Bai Kim, Ph.D., Asstt. Prof., Deptt. of Maths., West Virginia University, Morgantown, W. V. 26506, U. S. A.

19. Shri B. M. Jani, M.Sc., Research Fellow, Botany Deptt., University School of Science, Gujarat University, Ahmedabad-9.
20. Shri N. C. Jain, M.Sc., Lecturer, Deptt. of Maths., Shri G. S. Technological Institute, Indore.
21. Shri R. N. Jagetiya, M.Sc., Research Scholar, Deptt. of Maths., M. R. Engineering College, Jaipur.
22. Shri D. V. Jaiswal, M.Sc., Astt. Prof. of Maths., Deptt. of Maths., Holkar Science College, Indore.
23. Dr. T. K. Jha, M.Sc., Ph.D., Lecturer in Maths., B. N. College, Patna.
24. Dr. A. G. Jhingran, M.Sc , Ph.D., Astt. Research Officer, Central Inland Fisheries Research Station, 30 Pannalal Road, Allahabad.
25. Dr. C. N. Kachru, M.Sc., Ph.D., Prof. and Head of the Deptt. of Chemistry, J. & K. University, Amar Singh Bagh, Hazratbal, Srinagar.
26. Dr. K. N. Katiyar, M.Sc., Ph.D., F.R.E.S., F.E.S.I., F.A.Z.M.Z.S.I., Reader in Zoology, Deptt. of Zoology, University of Jodhpur, Jodhpur.
27. Dr. A. A. Khan, M.Sc., Ph.D., Lecturer, Deptt. of Chemistry, Aligarh Muslim University, Aligarh.
28. Shri M. A. Khan, M.Sc., Research Scholar, Deptt. of Maths., G.S.T.I., Indore.
29. Dr. I. K. Khanna, M.Sc., Ph.D., Lecturer, Deptt. of Maths., Banaras Hindu University, Varanasi.-5.
30. Shri L. K. Khanna, M.Sc., Research Scholar, School of Studies in Physics Vikram University, Ujjain.
31. Shri S. N. Khanna, M.Sc., F.P.S., Senior Geologist, Oil and Natural Gas Commission, Sibsagar (Assam).
32. Shri Prabhat Kumar, M.Sc., Research Assistant, Planning Investigation, Sub-Station, P.W.D. (Near Magadh Mahila College) Patna (Bihar).
33. Dr. Om Prakash Mall, M.Sc., Ph.D., Lecturer, Botany Deptt., Madhava College, Ujjain.
34. Shri A. B. Mathur, M.Sc., Lecturer, S.A.T.I., Vidisha.
35. Dr. G. D. Monghani, M.Sc., Ph.D., Lecturer in Chemistry, University of Jodhpur, Jodhpur.
36. Dr. Harihar Misra, M.Sc., Ph.D., Lecturer, Deptt. of Chemistry, University of Allahabad, Allahabad.
37. Shri K. N. Misra, M.Sc., Lecturer, Vikram M. P. H. S. School Narsingh Garh, Distt. Raj Garh (M. P.).
38. Mrs. P. K. Mital, M.Sc., Lecturer in Maths., Deptt. of Maths., Govt. College, Ajmer.
39. Shri Padam Chand Munot, M.Sc., Lecturer in Maths., University of Jodhpur, Jodhpur.
40. Shri D. B. Muley, M.Sc., Professor of Maths., Govt. Arts & Science College, Aurangabad.
41. Shri V. C. Nair, M.A., B.T., R.B.V., Lecturer in Maths., Regional College of Education, Ajmer.
42. Shri P. C. Pande, M.Sc., Reader and Head of the Deptt. of Geology, Amarvali Road, Nagpur.
43. Shri H. S. Pandey, M.Sc., Garden Supervisor, Central Circle, Botanical Survey of India, 10 Chatham Lines, Allahabad-2.
44. Shri S. R. Pant, M.Sc., Research Fellow in Maths., Deptt. of Maths., Ranchi University, Ranchi.
45. Dr. D. D. Pant, M.Sc., D.Phil., F.I.B.S., I.A.Sc., Professor and Head of the Botany Deptt., University of Allahabad, Allahabad.

46. Dr. B. V. Patil, M.Sc., Ph.D., Lecturer, Botany Deptt., Nagpur University, Nagpur.
47. Miss Saroj Panwar, M.Sc., Amar Niwas, P. W. D. Colony, Jodhpur.
48. Shri S. G. Parkash, M.Sc., Research Scholar, Physics Deptt., Allahabad University, Allahabad.
49. Dr. Rameshwar Prasad, M.Sc., D.Phil., D.Sc., Reader in Chemistry, Deptt. of Chemistry, Patna University, Patna-5.
50. Dr. Ram Rakshpal, M.Sc., D.Phil., Pool Officer, Deptt. of Chemistry, H.B.T.I., Kanpur (U. P.).
51. Shri K. D. Ramdeo, M.Sc., Lecturer in Botany, M. B. College, University of Udaipur, Udaipur.
52. (Km) Manjit Kaur Randhawa, M.Sc., Research Scholar, Botany Deptt., University of Saugar, Sagar.
53. Shri K. Kuppuswamy Rao, M.Sc., Lecturer, New Science College, Narayana Guda, Hyderabad-29.
54. Shri K. Keshav Rao, M.A., Research Scholar, Deptt. of Maths., Osmania University, Hyderabad-7.
55. (Miss) S. R. Sapre, M.Sc., Lecturer, Deptt. of Zoology, Govt. Arts & Science College, Durg.
56. Shri O. P. Saxena, M.Sc., Reader in Botany, University School of Sciences, Gujarat University, Ahmedabad-9.
57. Shri K. S. Sevaria, M.Sc., Lecturer, Deptt. of Maths., Govt. College, Ajmer.
58. Dr. P. Sen, M.Sc., Ph.D., Entomology Deptt., Faculty of Agriculture, University of Kalyani, Kalyani (Dt. Nadia).
59. Shri B. B. Sharma, M.Sc., Astt. Master, Th. D. S. B. Govt. College, Nainital.
60. Shri P. N. Shrivastava, M.Sc., Lecturer in Maths., Bundelkhand College, Jhansi.
61. Dr. Gulab Singh, M.Sc., D.Phil., Chemist, Office of the Agricultural Chemist to Govt. U. P., Kanpur.
62. Shri V. B. Singh, M.Sc., Research Scholar, Deptt. of Physics, Allahabad University, Allahabad.
63. Dr. K. P. Singh, M.Sc., Ph.D., Professor of Maths., Maths., Deptt., Banaras Hindu University, Varanasi-5.
64. Shri Firangi Singh, M.Sc., Lecturer in Maths., Deptt. of Maths, Govt. Engg. College Bilaspur.
65. Shri Lalji Singh, M.Sc., Research Scholar, College of Technology, Banaras Hindu University, Varanasi-5.
66. Dr. G. P. Singh, M.Sc., Ph.D., Cane Mycologist, Sugarcane Research Station, Gorakhpur.
67. Shri R. R. Prasad Singh, M.Sc., Lecturer in Botany, S. P. Jain College, Sasarm (E. Rly).
68. Dr. H. R. Singh, M.Sc., Ph.D., Lecturer in Zoology, K. N. Govt. College, Gyanpur.
69. Dr. S. S. Singh, M.Sc., Ph.D., Lecturer in Botany, Maharajas College, Chatarpur.
70. Shri M. K. Singhal, M.Sc., Research Scholar, Deptt. of Maths, University of Saugar, Sagar.
71. Shri Rewati Raman Prasad Sinha, M.Sc., Lecturer in Botany, S. P. Jain College, Sasaram.
72. Shri S. L. Soni, M.Sc., Astt. Prof. of Maths., Govt. College, Ganj Basada. Vidisha.

73. Shri D. P. Tewari, M.Sc., Research Scholar, Deptt. of Physics, Allahabad University, Allahabad.
74. Shri Basant Tiwari, M.Sc., Research Fellow, Plant Physiology Section, College of Agriculture, Banaras Hindu University, Varanasi-5.
75. Shri Philip Joseph Thakur. M.Sc., Lecturer, Deptt. of Maths., L. S. College, Bihar University, Muzaffarpur.
76. Shri S. K. Tiwari, M.Sc., Research Scholar, Deptt. of Maths., Vikram University, Ujjain.
77. Dr. I. P. Varshney, M.Sc., Ph.D., D.Sc., F.R.I.C., Prof. and Head of the Chemistry Deptt., G. S. Technological Institute, Indore-3.
78. Shri D. N. Vishnoi, M.Sc., Senior Physicist, Govt. of India Ministry of Mines & Metals, New Secretariat Buildings, Nagpur.
79. Shri A. B. Vyas, M.Sc., Lecturer, Deptt. of Zoology, Gujarat University, Ahmedabad-9.
80. Shri D. K. Wagh, M.Sc., Lecturer, Deptt. of Applied Maths., Shri G. S. Technological Institute, Indore.
81. Shri Ram Bali Ram Yadava, M.Sc., Research Scholar, Plant Physiology Section, Banaras Hindu University, Varanasi-5.

FELLOWS

We are happy to announce the election of the following members as Fellows of the Academy during the year 1968.

1. Prof. J. N. Chatterjee, D.Sc., D.Phil.(Oxon), F.R.I.C., Head of the Department of Chemistry, Patna University, Patna-5.
2. Prof. D. D. Pant, M.Sc., D.Phil, F.L.S., F.A.Sc., Prof. and Head of the Botany Department. Allahabad University, Allahabad.
3. Dr. Ram Ballabh, M.Sc., Ph.D., Prof. and Head of the Department of Mathematics, University of Lucknow, Lucknow.
4. Dr. H. C. Khare, M.Sc., Ph.D., Reader and Head, Mathematics Deptt., University of Allahabad, Allahabad.
5. Dr. Kailash Nath Srivastava, M.Sc., D.Phil., D.Sc., Reader in Mathematics, M.A. College of Technology, Bhopal.
6. Dr. V. G. Jhingran, M.Sc., Ph.D., Director, Central Inland Fisheries Research Institute, Barrackpore.
7. Dr. S. R. Mukerji, M.A., D.Phil., Reader in Engineering Mathematics, Engineering College, Banaras Hindu University, Varanasi-5.
8. Dr. S. N. Srivastava, Ph.D., (Luck.), Ph.D.(Cantab), F.R.I.C., Head of the Chemistry Department, Agra College, Agra.
9. Dr. Krishna Kant, M.Sc., D.Phil., Reader in Chemistry, Jodhpur University, Jodhpur.
10. Dr. Y. K. Gupta, M.Sc., D.Phil., Reader in Chemistry, University of Rajasthan, Jaipur.

OBITUARY

The Academy condoned the sad and untimely demise of the following Honorary Fellows, Fellows and Members of the Academy during the year 1968 :

1. Prof. Otto Hahn, N. L., Hony. Fellow.
2. Prof. Paul Pascal, Hony. Fellow.
3. Prof. A. C. Banerji, Founder-Fellow and ex-President of the Academy.
4. Shri G. D. Srivastava, Fellow.
5. Prof. H. D. Bagchi, Fellow.
6. Dr. B. S. Chandel, Member.

MEETINGS

During the year under review, ten meetings of the Council, and of the General Body each and two meetings of the Fellows were held. Basides transaction of business, papers were read and discussed at the ordinary meetings.

THIRTY-SEVENTH ANNUAL SESSION

The thirty-seventh Annual Session of the Academy was held at Ahmedabad from February 1—4, 1968 at the invitation of the Gujarat University. At that session the number of delegates was larger than usual and it drew participants from all over the country. Prof. K. Banerjee, President of the Academy, could not attend the session owing to ill-health. So, his presidential address was presented by Prof. K. N. Mathur.

Dr. Umashanker Joshi, Vice-Chancellor of the Gujarat University and Chairman of the Reception Committee, welcomed the guests. The session was inaugurated by Shri Shriman Narayan, Rajyapal, Gujarat Pradesh and was presided over by the Chief Minister Shri Hitendra Desai.

Prof. K. N. Mathur of National Physical Laboratory, New Delhi, presided over the Physical Sciences Section while Prof. V. Puri of School of Plant Morphology, Botany Deptt., Meerut University and Principal, Meerut College, presided over the Biological Sciences. Nearly 200 papers were presented in the Biological Section and 100 papers in the Physical Sciences Section.

A Symposium on the "Diversities in Plant and Animal Population" was organized by Dr. S. C. Pandeya of the Botany Deptt., Gujarat University.

The Rajyapal of Gujarat Pradesh was 'At Home' to the delegates at the Governor's Residence. Besides there were several other social engagements and entertainments.

The authorities of the Gujarat University spared no pains to make the session a grand success. The Academy is grateful to Dr. Umashankar Joshi, the Vice-Chancellor, Prof. J. J. Chinoy, Director and Dr. S. C. Pandeya, local secretary and other authorities of the University and the Reception Committee.

COUNCIL

The following constituted the Council of the Academy during 1968.

President

1. Dr. R. K. Saksena, D.Sc., F.N.I., F.N.A.Sc., Retired Prof. of Botany, University of Allahabad, Allahabad.

Vice-Presidents

2. Prof. P. L. Srivastava, M.A., D.Phil., F.N.I., F.N.A.Sc., Ex-Vice-Chancellor, Bihar University 7, Lajpartai Road, Allahabad.
3. Prof. Ram Behari, M.A., Ph.D., Sc.D., F.N.I., F.A.Sc., F.N.A.Sc., Ex.-Vice-Chancellor, University of Jodhpur, 80, Darya Gunj, Delhi–6.

Honorary Treasurer

4. Prof. R. S. Mishra, M.Sc., Ph.D., D.Sc., F.N.I., F.N.A.Sc., Head of the Department of Mathematics, University of Allahabad, Allahabad.

Foreign Secretary

5. Prof. N. R. Dhar, D.Sc., F.R.I.C., F.N.I., F.N.A.Sc., I.E.S., (Retd.), Foreign Associate Member of French Academy of Agriculture and Corresponding Member of French Academy of Science, Director, Sheila Dhar Institute of Soil Science, University of Allahabad, Allahabad.

General Secretaries

6. Prof. M. D. L. Srivastava, D.Sc., F.N.A.Sc., U. G. C. Retired Professor of Zoology Department, University of Allahabad, Allahabad.
7. Dr. A. C. Chatterji, D.Sc., Dr.Ing., F.N.A.Sc., Ex-Vice-Chancellor, Gorakhpur University, C/o Department of Chemistry, University of Lucknow, Lucknow.

Members

8. Prof. A. C. Banerji, M.A., M.Sc., F.R.A.S., F.N.I., F.N.A.Sc., I.E.S., (Retd.), Ex-Vice Chancellor, University of Allahabad, Allahabad.
9. Prof. S. P. Tandon, M.Sc., D.Phil., Head of the Chemistry Department, University of Allahabad, Allahabad.
10. Prof. Krishnaji, M.Sc., Head of the Department of Physics, University of Allahabad, Allahabad.
11. Prof. G. P. Sharma, M.Sc., Ph.D., F.N.I., F.A.Z., F.I.A.Z., F.Z.S., F.Z.S.I., F.R.M.S., F.N.A.Sc., Head of the Dept. of Zoology, Punjab University, Chandigarh-3
12. Prof. S. N. Ghosh, D.Sc., F.N.A.Sc., J. K. Institute of Applied Physics, University of Allahabad, Allahabad.
13. Prof. D. Sharma, M.Sc., D.Phil., F.N.A.Sc., Head of the Dept. of Physics, University of Gorakhpur, Gorakhpur.
14. Dr. C. Thakur, M.Sc., Ph.D., F.N.A.Sc., Principal and Regional Director, Agricultural Research Institute, Dholi (Dt. Muzaffarpur), Bihar.
15. Prof. R. N. Tandon, M.Sc., Ph.D., D.I.C., F.A.Sc., F.N.I., F.N.A.Sc., U.G.C., Retd. Prof. of Botany, Botany Department, University of Allahabad, Allahabad
16. Dr. Arun K. Dey, M.Sc., D.Phil., D.Sc., F.N.A.Sc., Department of Chemistry, University of Allahabad, Allahabad.

REPRESENTATIONS ON OTHER ORGANISATIONS

The Academy was represented by the following members on other organizations and learned bodies.

1. Prof. N. R. Dhar, D.Sc., F.N.I., F.R.I.C., F.N.A.Sc., I.E.S. (Retd.), Member of the Indian National Commission for Co-operation with UNESCO.
2. Prof. R. S. Mishra, M.Sc., Ph.D., D.Sc., F.N.I., F.N.A.Sc., Additional Member, Council of the National Institute of Sciences of India, New Delhi.
3. Prof. M. D. L. Srivastava, D.Sc., F.N.A.Sc., a representative of the Academy on the Court of Lucknow University.

FINANCES

The financial position of the Academy is given in the Financial Statement for 1967-68 ending on the 31st March, 1968.

The Academy is thankful to the following for the assistance received from them.

1. The Government of India.
2. The Government of Uttar Pradesh.
3. The University of Allahabad.
4. The National Institute of Sciences of India, New Delhi.

Owing to the paucity of funds the Academy still continues to work under financial strain, the publication section and the library require to be strengthened to meet the growing needs of the Academy and more office and administrative staff is needed for efficient working. The Academy is in urgent need of funds to clear its liabilities to the press and looks for extra non-recurring grants from each of the above sources.

PUBLICATIONS

The publications are somewhat in arrears, in spite of our efforts to bring it up to date. Apart from financial difficulty, one of the presses to which the printing was assigned is unable to print our journal after executing a part of it with the result that later proceedings are being printed while part III of Section A of 1966 is not yet out. Besides, we are unable to procure good quality of printing paper. We have a large number of approved papers in hand for publication. It will be appreciated if the contributors at their own initiative will reduce the length of the papers and the number of figures, diagrams and photographs to secure economy in printing.

LIBRARY

The re-organization of the library needs further attention. The foreign periodicals received in exchange require binding the cost whereof is considerable. There is an increasing demand for exchange with our Proceedings. The library requires considerable improvement to bring it up to the standard expected of a scientific library. Financial stringency prevents us from bringing the library to the condition of maximum utility.

GENERAL OBSERVATIONS

This Academy, which was established over thirty-eight years ago, is the oldest Scientific Academy in this country. It has on its rolls representatives from every part of the country and from various disciplines of scientific activity. Many foreign scientists and some of our statesmen are associated with us as honorary Fellows of the Academy. The Academy has always welcomed scientific workers and technologists. We seek the co-operation of all those interested in science in working for the scientific advancement of the country. It is hoped that both the Uttar Pradesh and the Union Government will increase their grants which at present have become alarmingly inadequate, owing to rising prices and our expanding needs.

ACKNOWLEDGEMENTS

We have great pleasure in recording our thanks and appreciation for the ungrudging help and co-operation which we have received in full measure from the referees of papers, the scrutinizers of voting papers, the Members of the Academy and the printing presses. We also acknowledge the missionary zeal of the two Officers-on-Special Duty, who have voluntarily agreed to work without any honorarium. Lastly, our thanks are due to the staff for their untiring work and devotion to duty.

FINANCIAL STATEMENT FOR 1967–68

RECEIPTS		Rs.	PAYMENTS		Rs.
Opening balances					
Cash at Bank	2,075·67		Establishment	...	6,877·77
Cash in hand	25·43	2,101·10	Dearness Allowance etc.	...	4,900·34
Grants			Provident Fund	..	767·20
Recurring maintenance grant from Govt. Uttar Pradesh	...	6,000·00	Postage	...	2,901·88
Grant from Allahabad University	...	2,000·00	Printing and Stationery	...	489·16
Grant from the National Institute of Sciences of India, New Delhi	...	2,000·00	Miscellanous Expenditure	...	513·01
Publication grant from the Govt. of India, New Delhi	...	10,000·00	Bicycle Repairs	...	8·68
Subscription from the members	...	5,350·00	Electric charges	...	108·45
Sale of Proceedings	...	6,185·37	Telephone charges	...	183·05
Cost of Reprints	...	735·37	Allowance to O. S. D.	...	1,200·00
Bank Commission	...	23·62	Revenue Stamps	...	12·40
Provident Fund Contribution by the staff	...	338·60	Annual Session expenses	...	1,912·58
Loan realised in respect of Provident Fund Money	...	90·00	Repairs of Machine	...	4·00
Refund of Loan from Babulal, a peon of the Academy	...	10·00	Bank charges	...	120·50
Loan from Reserve Fund	...	3,783·08	Audit Fees	...	75·00
			Advertisement charges	...	95·34
			Cost of Publication		
			Mission Press	1,627·79	
			Capital Press	12,390·24	
			Cost of printing paper	2,541·07	
			Cost of other paper	78·64	16,637·74
					36,807·10
			Closing Balance		
			Cash at Bank	...	1,810·04
GRAND TOTAL		38,617·14	GRAND TOTAL		38,617·14

Note : The Reserve Fund a/c has been depleted from Rs. 23,968·07 to Rs. 20,184·99.

Examined with the books and vouchers, certified correct to the best of our knowledge, information and belief.

(Sd.) ILLEGIBLE
for G. P. JAISWAL & Co.
Chartered Accountants.

THE

National Academy of Sciences, India

THIRTY-EIGHTH ANNUAL SESSION

RANCHI, March 17-19, 1969

ABSTRACT OF PAPERS

SECTION OF PHYSICAL SCIENCES

NATIONAL ACADEMY OF SCIENCES
LAJPATRAI ROAD
ALLAHABAD
1969

SECTION OF PHYSICAL SCIENCES

ABSTRACT OF PAPERS

1. A note on Certain Bilinear and Bilateral generating relations for the Laguerre Polynomials

H. M. SRIVASTAVA, *Department of Mathematics, West Virginia University, Morgantown, West Virginia, U. S. A.*

The author presents here a systematic analysis of certain bilinear and bilateral generating relations associated with the generalized Laguerre polynomials $\{L_n^{(\alpha)}(x)\}$ defined by

$$(1-t)^{-1-\alpha}\exp\left(-\frac{xt}{1-t}\right)=\sum_{n=0}^{\infty}L_n^{(\alpha)}(x)\,t^n.$$

It is shown that the four formulas proved recently by R. N. Jain [*Proc. Nat. Acad. Sci. India Sect. A*, **36** : (1966), 937–944] are only specialized or limiting forms of the results of A. Erdélyi [*Compositio Math.*, **6** : (1939), 336–347], J. Meixner [see *Deutsch Math.*, **6** : (1942), 341–349], and the author [*Amer. Math. Soc. Notices* **15** : (1968), 634 635 ; *Math. Comp.*, **23** : (1969). in press ; *Glasnik Mat. Ser. III*, **4** : (1969), to appear ; etc.] who in an attempt to give extensions of the well-known Hille-Hardy formula has applied the Laplace and the inverse Laplace transform techniques and the method of multi-dimensional mathematical induction in order to derive several new and distinct bilinear and bilateral generating relations involving certain classes of generalized hypergeometric functions in one and more variables which unify scores of hitherto scattered results in the theory of generalized hypergeometric polynomials [*see* also the author's paper in *Proc. Cambridge Philos. Soc.*, **65** : (1969)].

2. Influence of Algae on Crop Production in presence of Organic matter and Phosphates.

N. R. DHAR AND OM PRAKASH, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Saccharum munja (Sarkanda) at the rate of 10 tons per acre along with and without phosphates in the form of Tata basic slag (Thomas slag) at the rate of 50 lbs. P_2O_5 per acre were applied in a field trial experiment conducted at Gyanpur (Varanasi district). The Algae, Anabaena Naviculoides, Chlorella vulgaris and Tolypothrix tenuis were also inoculated in the required plots.

The results indicated that the paddy yield was markedly increased with the application of organic materials when incorporated with and without phosphates. It was also observed that there was small increase in yield due to Anabaena naviculoides and Tolypothrix tenuis while due to Chlorella vulgaris the increase in yield was negligible. Further it has been found that comparison to algae alone the increase in yield was higher in plots in which algae was inoculated with organic matter and phosphate.

3. Influence of Algae in presence of Organic matter and Phosphates on "Carbon Nitrogen Transformation" in Gyanpur (Varanasi) alluvial soil

N. R. Dhar and Om Prakash, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Paragrass and sunhemp along with Tata basic slag and German basic slag were mixed with Gyanpur (Varanasi) alluvial soil. Anabaena naviculoides, Chlorella vulgaris and Tolypothrix tenuis were inoculated in the required sets. Analysis for carbon and nitrogen were carried out after 60, 120, 180 and 240 days.

It was observed that compared to Anabaena and Tolypothrix, paragrass and sunhemp were more useful in fixing atmospheric nitrogen. In presence of phosphates the nitrogen fixation was enhanced. Algal growth and nitrogen fixation by algal showed a considerable increase in presence of organic matter and phosphates.

Some saving of carbon was observed in the systems inoculated with algae ; the order of carbon saving being Chlorella > Tolypothrix > Anabaena.

With paragrass the oxidation of carbon and fixation of nitrogen was relatively higher when compared to sunhemp. This may be due to higher C/N ratio in paragrass than that of sunhemp.

4. Certain Generalized Neumann Expansions associated with the Kampé de Fériet function

H. M. Srivastava, *Department of Mathematics, West Virginia University, Morgantown, West Virginia, U. S. A.* and Martha C. Daoust, *Kanawha Valley Graduate Center, West Virginia University, Charleston, West Virginia, U. S. A.*

In the course of an attempt to unify several recent results of the first author [*cf. Proc. Cambridge Philos. Soc.*, **62** : (1966), 245-247 ; *ibid*, **63** : (1967), 425-429 etc.] and others [see *e.g. Proc. Cambridge, Philos. Soc.* **64** : (1968), 413-416] the writers prove here a general Neumann expansion for the generalized Kampé de Fériet function introduced earlier by them in the form

$$S_{C:D;D'}^{A:B;B'}\left(\begin{matrix}x\\ y\end{matrix}\right) \equiv S_{C:D;D'}^{A:B;B'}\left(\begin{matrix}[(a):\theta,\phi]:[(b):\psi];[(b'):\psi'];\\ [(c):\delta,\varepsilon]:[(d):\eta];[(d'):\eta'];\end{matrix}\ x, y\right)$$

$$= \sum_{m,n=0}^{\infty} \frac{\prod_{j=1}^{A}\Gamma[a_j+m\theta_j+n\phi_j]\prod_{j=1}^{B}\Gamma[b_j+m\psi_j]\prod_{j=1}^{B'}\Gamma[b'_j+n\psi'_j]}{\prod_{j=1}^{C}\Gamma[c_j+m\delta_j+n\varepsilon_j]\prod_{j=1}^{D}\Gamma[d_j+m\eta_j]\prod_{j=1}^{D'}\Gamma[d'_j+n\eta'_j]}\frac{x^m}{m!}\frac{y^n}{n!}$$

where the θ's, ϕ's, δ's, ε's, η's, ψ's, etc. are positive real constants.

It is proved that the main expansion formula which involves an infinite series of Meijer's *G*-function and Fox's *H*-function can formally be extended to hold for a generalized Lauricella function in several arguments.

5. A Spectrophotometric Study of the Chelates of Chromotrope 2R with Praseodymium, Neodymium, Samarium and Europium.

V. L. SHAH AND S. P. SANGAL, *Laxminarayan Institute of Technology, Nagpur University, Nagpur.*

The formation of the violet coloured complexes of 4-5 dihydroxy-3- phenylazo-2, 7 naphthalenedisulphonic acid, (di Na salt) (Chromotrope 2R) and praseodymium, neodymium, sararium and europium has been reported. The studies include the determination of composition stability and other characteristics of the chelates formed. The absorbance curves of the complexes show the wavelength maxima of all the chelates is at 550 mμ. The composition of the chelates have been established by two different methods *i.e.* the method of continuous variation and mole ratio method and the stoichiometric ratio came to be 1 : 1 (metal : ligand). The apparent stability constants of the chelates are determined by the mole ratio method and Dey *et al* method at pH 6·0, at 28°C. The mean values of log *k* are 4·5, 4·7, 4·8 and 4·3 for Pr (III), NNd (III) Sm (III) and Eu (III) Chelates respectively.

6. Influence of 'Algae and Basic slag' in presence of Organic materials on the availability of soil phosphates

N. R. DHAR AND OM PRAKASH, *Sheila Dhar Institute of Soil Science, University of Allahabad*

The algae, Chlorella vulgaris, Anabaena naviculoides and Tolypothrix tenuis were inoculated in the soil with organic matter (Paragrass and sunhemp) and phosphate in the form of Tata basic slag and German basic slag at the rate of 0·5% P_2O_5 level.

Analysis after 240 days showed that when algae was inoculated with organic matter and phosphates the maximum increase in available phosphorus was observed due to slow oxidation of carbon and when algae was inoculated with soil alone there was also small increase in the availability of phosphates due to the carbonic acid and other weak organic acids formed in the slow oxidation of algal substance. These carbonic acid and weak organic acids help in the availability of phosphates by converting insoluble Tri-calcium Phosphate into soluble form *i.e.* di and mono-calcium phosphates.

7. Reclamation of Gyanpur (Varanasi) alkali soil by a mixture of Organic matter and Phosphates

N. R. DHAR AND OM PRAKASH, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Organic materials like waterhyacinth (Eichornia crassipes), Cactues (opuntia) mixed leaves and coal along with different phosphates like Tata basic slag, German basic slag, Kulti basic slag, Trichnopoly rock phosphate and Bihar rock phosphate were used to study the reclamation of alkali soil (pH 9·6) from Gyanpur (Varanasi).

Analysis after 60, 120, 180 and 240 days showed that the organic materials considerable increased the nitrogen of the soil and this nitrogen fixation was much enhanced by the addition of phosphates.

In presence of phosphates and organic materials are increase in the exchangeable calcium, available phosphate, electrical conductivity and the no. of total Bacteria, Azotobacter and Fungi was observed. Moreover, the pH of the soil was reduced after 240 days from 9·6 to 7·40.

Thus it has been concluded that the mixture of organic materials and phosphates as uses effective in reclaiming alkali soils.

8. Influence of Toxic Organic substances such as Mono-Dihydroxy Derivatives of Benzene on Photo-chemical nitrogen fixation

N. R. Dhar and A. K. Sen, *Sheila Dhar Institute of Soil Science, University of Allahabad*

The effect of mono- and dihydroxy derivatives of benzene on the photochemical nitrogen fixation were studied, taking surfaces like sand, TiO_2, Fe_2O_3, ZnO and $FePO_4$ etc. The experiments were conducted both under sterile and unsterile conditions, and in light and dark in order to compare and differentiate the microbial and photo-chemical nitrogen fixation. Samples were analysed for N, C, P_2O_5, ammoniacal nitrogen, nitrate nitrogen at an interval of 50 days. The microbial growth was observed by counting Azotobacter during the same interval.

The results showed the marked influence of light in nitrogen fixation. It was observed that the fixation of nitrogen was enhanced in the presence of phosphates.

9. Further properties of the Generalized Whittaker transform

H. M. Srivastava, *Department of Mathematics, West Virginia University, Morgantown, West Virginia, U. S. A.*

A unification of the various generalizations of the classical Laplace transform due to C. S. Meijer [*Nederl. Akad. Wetensch. Proc. Ser. A*, **43** (1940), 599-608 and 702-711 ; *ibid.*, **44** (1941), 727-737 and 831-839] and R. S. Varma [*Current Sci.*, **16** (1947), 17-18 ; *Proc. Nat. Acad. Sci. India Sect. A*, **20** (1951), 209-216] was introduced recently by the author [*Mathematica*, **10** (1968), 385-391 ; *see* also *Nederl. Akad. Wetensch. Proc. Ser. A*, **71** (1968), 316-320] in the elegant form

$$(*) \qquad S^{(\rho,\ \sigma)}_{q,\ k,\ m}[f(t) : p] = \int_0^\infty (pt)^{\sigma-\frac{1}{2}}\, e^{-\frac{1}{2}qpt}\, W_{k,m}(\rho pt)\, f(t)\, dt$$

where, if $f(t) = 0\ (t^\lambda\, e^{\alpha t})$ for large t, and $f(t) = 0\ (t^c)$ for small t, then $Re[(q+\rho)\, p - 2\sigma] > 0$, and $Re(\sigma + c + 1) > |\, Re(m)\, |$. In a subsequent paper to appear in Vol. **72** (1969) of the *Nederl. Akad. Wetensch. Proc. Ser. A* [*see* also *Amer. Math. Soc. Notices*, **15** (1968), 615)], its relationships with other integral transforms were studied.

In this paper the author aims at presenting a systematic discussion of several additional properties of the generalized integral transform defined by (*)

10. On the Generalized Appell Function and a Conjecture of Lauricella

H. M. SRIVASTAVA, *Department of Mathematics, West Virginia University, Morgantown, West Virginia, U. S. A.*

As long ago as 1893 G. Lauricella [*Rend. Circ. Mat. Palermo*, **7** (1893), 111–158] generalized the four Appell functions to functions in n arguments and denoted his multiple hypergeometric series by $F_A^{(n)}$, $F_B^{(n)}$, $F_C^{(n)}$ and $F_D^{(n)}$. For $n=2$, these four functions reduce to Appell's F_2, F_3, F_4 and F_1 respectively. When $n=3$, Lauricella conjectured the existence of ten hypergeometric functions of three variables in addition to $F_A^{(3)}$, $F_B^{(3)}$, $F_C^{(3)}$ and $F_D^{(3)}$. Explicit forms of the fourteen functions belonging to Lauricella's set of triple hypergeometric functions were indeed given by Lauricella himself [*loc. cit.*, p. 114] who denoted them by $F_1, F_2, \ldots\ldots, F_{14}$, where F_1, F_2, F_5 and F_9 are the same as $F_A^{(3)}$, $F_B^{(3)}$, $F_C^{(3)}$ and $F_D^{(3)}$ respectively.

In the course of a detailed and systematic study of Lauricella's triple hypergeometric functions in the notation of S. Saran [*cf. Ganita*, **5** (1954), 77-91], the author [*Ganita*, **15** (1964), 97–108 ; *Publicationes Math.*, **12** (1965), 65–74 ; *Revista Mat. Fis. Teorica Ser. A*, **16** (1966), 7–14 ; *Proc. Nat. Acad. Sci. India, Sect. A*, **36** (1966), 377–385 ; etc.] came across three new and distinct hypergeometric functions of three variables, viz. H_A, H_B, H_C which do belong to the Lauricella set inasmuch as they are generalizations of the Appell functions [*See* also the author's subsequent work presented at the thirty-sixth annual session of the National Academy of Sciences of India and published in *Rend. Circ. Mat. Palermo Ser. II*, **16** (1967) 1–17].

The present paper attempts at answering, though only partially, the natural question whether or not the three functions H_A, H_B and H_C are covered by Lauricella's conjecture [*loc. cit.*, pp. 112 and 114], and if so, how ?

11. Retentivity and release of Water Soluble Phosphorus from soils when treated with Phosphatic fertilizers

N. R. DHAR AND M. M. VERMA, *Sheila Dhar Institute of Soil Science, University of Allahabad*

To the soil samples different phosphatic fertilizers in the form of phosphoric acid, superphosphate, dicalcium dihydrate, German basic slag and Tata basic slag were added at the rate of 50 and 100 lbs of P_2O_5 per acre. A moisture level of 20% was supplied and maintained throughout the experiment. The contents were allowed to incubate at room temperature for a period of 90 days. The combined soil solutions were examined periodically for total amount of phosphorus released.

Results showed that the amount of water soluble phosphorus released by the various soils treated with different phosphatic fertilizers at the moisture level of 20% is greater with 100 lbs/acre treatment of P_2O_5 and decreased with the decrease in the dose of phosphorus. It has been observed in the case of phosphoric acid, superphosphate and dicalcium phosphate treatments maximum release is obtained upto 30 days and after that there is a decrease. The decomposition of basic slags in the soil is a slow process. However, with increasing time the decomposition is slightly increased resulting in the increased release towards the end of the investigations. Basic slags are more durable and have potentially a very high residual effect.

12. Effect of Waterhyacinth (*Eichornia crassipes*), Wheatstraw and mixed leaves with and without phosphate on Crop production and reclamation of alkali soil

N. R. Dhar and Om Prakash, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Energy materials like waterhyacinth (eichornia crassipes), wheat straw and mixed leaves at the rate of 10 tons per acre along with and without phosphate like Tata basic slag, Kulti basic slag and Durgapur basic slag at the rate of 50 lbs. P_2O_5 per acre were applied in Gyanpur (Varanasi) alkali soil (pH 9·6).

The results indicated that better yield of paddy was obtained, when mixture of organic materials were ploughed with basic slag than alone. The orders of increase in the yield due to various treatments was as follows :

Waterhyacinth + T. B. S. > wheat straw + T. B. S. > mixed leaves + T. B. S.

A usual crop rotation (paddy—wheat—paddy) was taken. It was observed that the 2nd and 3rd succeeding crops fetched more yields than the first crop because the alkalinity of the soil reduced to greater extent by carbonic acid and other organic acids formed in the slow oxidation of organic matter. The oxidation of organic matter was enhanced by addition of basic slags.

13. Washing of naturally occurring Phosphate and Lime from different soils

N. R. Dhar and M. M. Verma, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Six different soil samples were experimented in the Laboratory, for washing of naturally occurring phosphate and lime in soil water ratios of 1 : 2·5, 1 : 5, 1 : 10, 1 : 25 and 1 : 50. These varying soil water ratios were taken in order to imitate the leaching at different rainfalls.

It has been observed that the phosphate rich soils loses more phosphate per washing than in phosphate poor soil. It is also evident from the results that as the soil water ratio is increased, the amount of P_2O_5 lost is also increased. Cultivated soils lost more of P_2O_5 as compared to uncultivated soils per washing. Regarding the CaO leaching it has been noticed that soil rich in CaO lost more lime than soil poor in CaO. As the soil water ratios are increased, the amount of lime leached is also appreciably increased.

14. Adsorption of Phosphate by Iron Ores and Bauxite

N. R. Dhar and M. K. Dhar, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Adsorption of phosphate at different concentration by iron ores collected from different parts of India and samples of Bauxite have been studied. It has been observed that the amount of phosphate adsorbed by the iron ores mainly depends on the amount of iron present in the ores. Ores riches in iron was found to adsorb maximum of phosphate than less in iron.

Bauxite was found to adsorb more phosphate in comparision to iron ores.

15. Adsorption of Phosphate by Ferric Hydroxide and Aluminium Hydroxide

N. R. Dhar and M. K. Dhar, *Sheila Dhar Institute of Soil Science, University of Allahabad*

From the study of adsorption of phosphate at different concentration by freshly prepared ferric hydroxide and Aluminium hydroxide, it has been observed that the adsorption decreases as the temperature increases when these substances are heated from half an hour to 5 hours. No appreciable adsorption of phosphate takes place after 5 hours.

Moreover it has been noted that in case of Aluminium hydroxide adsorption is more as compared to Ferric hydroxide.

16. Slow oxidation and Nitrogen Fixation by Coal Powder in the presence of Calcium Oxide, Calcium Carbonate and Phosphates

N. R. Dhar, A. K. Sen and S. N. Singh, *Sheila Dhar Institute of Soil Science, University of Allahabad*

A large number of laboratory experiments were conducted to find out the efficiency of coal in nitrogen fixation.

Coal is considered as an inert carboneceous material but experiments conducted showed that it can undergo slow oxidation and fixed the atmospheric nitrogen.

Coal powder (100 mesh) was taken for studies and different doses of CaO, $CaCO_3$ and phosphates were added to find out this effect. Results indicate that, even though coal undergo oxidation rather slowly than other carbonecoeus materials, it can fix atmospheric nitrogen. In presence of rock phosphate the efficiency of nitrogen fixation and the rate of oxidation is higher. CaO and $CaCO_3$ also enhances the rate of oxidation. The favourable results obtained indicate that waste coal can be utilised in increasing the humus status of soils.

17. Influence of light on Mineralization of Nitrogen in composting

N. R. Dhar, S. N. Singh and A. K. Sen, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Compost were prepared from mixed leaves (C/N ratio 47·1) incorporated with nitrogen (1% N as urea) and phosphates (1·5% P_2O_5 as Basic slags and Super Phosphates) separately. A set of pits were exposed to sunlight and the corresponding set were covered with black Tarpoline cloth to neglect sunlight completely. After 45, 90 and 120 days the composts were analysed for their Chemical composition. Average temperature was also recorded. It has been observed that the composts phosphated at the rate of 1·5% P_2O_5 are richer in N.P.K. as compared to compost where nitrogen was added at the rate of 1%.

Maximum decomposition was obtained after 90 days in the compost which were exposed to sunlight and its nutrient content was also higher as compared to compost prepared in the dark.

18. Improvement of soil fertility by the application of organic materials and phosphates

N. R. Dhar, S. N. Singh and Om Prakash, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Organic materials like Town Refuse and Wheat straw at the rate of 10 tons per acre were applied to the soil in the pots along with Basic slag and Ammonium phosphate at the rate of 50 lbs P_2O_5 per acre.

A marked increase in the wheat yield was obtained in the wheat straw+ ammonium phosphate and straw + Tata Basic slag treatments over control.

The soil analysis after harvest showed a higher nutrient level in organic materials incorporated with slag. The successive paddy crop fetched more yield with organic materials + slag than organic materials with ammonium phosphate.

Tata Basic slag checked the loss of nitrogen and also helped in the fixation of atmospheric nitrogen by the slow oxidation of these organic materials, thus a better residual effect.

19. Control of Perennial weed *Cynodon dactylon* through mechanical and chemical (Dowpon and T. C. A.) methods in fallow fields

S. S. Singh, *B. R. College, Bichpuri, Agra*

An experiment was planned to formulate the practice for the control of *Cynodon dectylon* and was conducted in the Kharif and Rabi seasons of the year 1965-66 at B. R. College, Bichpuri, Agra. Dowpon application at the rate of 5 lbs and 10 lbs per acre and Tri-chloro acetic acid (T.C.A.) at the rate of 10 lbs and 20 lbs per acre with and without mechanical operations were applied on the aerial part of *Cynodon dactylon.*

It has been observed that the extent of eradication of the weed with the Dowpon application at the rate of 10 lbs concentration over the lower rate *i.e.* 5 lbs per acre proved to be more effective. T.C.A. application improved the weed control efficiency with hot weather cultivation. Higher dose of T.C.A. *i.e.* 20 lbs/ acre was slightly better than lower rates of its application. In plots treated with hot weather followed by rainy season cultivation T.C.A. has significantly no effect as weed control.

20. After effect of Dowpon and T.C.A. on plant population and yield of pea crop

S. S. Singh, *B. R. College, Bichpuri, Agra*

An experiment was planned in Kharif and Rabi seasons of the year 1965-66 at Balwant Vidyapeeth Agricultural Research Station, Bichpuri, Agra, to see toxicity of chemicals used as weedicide. Dowpon was applied at the rate of 5 and 10 lbs per acre and T.C.A. was applied at the rate of 10 lbs and 20 lbs per acre with and without mechanical operations in the field.

It has been observed that the grain and straw yields of pea were adversely affected in plots treated with T.C.A. Though the extent of weed eradication was fairly good even then plant population and yield per plant and per hectare was very low. The lower yield was due to detrimental after effect of T. C. A. as its toxicity was reported to persist to a longer duration upto 70 days.

21. Effect of light on mineralisation of nitrogen fixation by "Blue Green Algae" in medium containing different Phosphate and Glucose

N. R. Dhar, Om Prakash, S. N. Singh and S. S. Singh, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Different phosphates as mono calcium phosphate, Potassium dihydrogen phosphate and sodium dihydrogen phosphate at the rate of 0·1% P_2O_5 and 0·05% P_2O_5 were added in 150 cc. of the medium containing 3 ml. of 30% glucose solution. After sterilization few cells of Anabaena naviculoides and Tolypothrix tenuis were inoculated and the flask were exposed to 100 watt bulb for 12 hour daily.

Analysis after 45, 90 and 180 days showed that in presence phosphates there is more nitrogen fixation and increase in available phosphates. The maximum fixation of nitrogen by Anabaena Tolypothrix in different phosphates were in the following order :

$$NaH_2PO_4 > KH_2PO_4 > Ca(H_2PO_4)_2$$

It seems that along with K, Mg, Fe, Ca in the medium, sodium is also an essential element for the growth of the blue green algae. It is also interesting to note that the growth of the algae is more when lower concentrations of phosphates are used, then, when they are used in higher concentration.

22. Effect of sunlight on mineralization of nitrogen in composting

N. R. Dhar, Om Prakash, S. S. Singh and R. P. Singh Chauhan, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Different composts were prepared with different composition from mixed weeds (chapped) having C/N ratio 50 : 1, coal and Tata Basic Slag. A set of pits were exposed to sunlight and the corresponding sets were covered with black tarpoline cloth to avoid sunlight. The composts were analized 40, 80 and 120 days. The average temperature was also recorded.

It has been observed that the composts phosphated with higher doses of T.B.S. were richer in N.P.K. contents. Maximum decomposition was obtained after 80 days in the sets exposed to sunlight and nutrient contents were also higher as compared to dark sets. The bacterial population was also lower, particularly Azotobacter count, in the light sets and higher in covered sets.

23. Effect of nitrogenous compound on the growth of Algae in pure culture containing cane sugar solution

N. R. Dhar, Om Prakash, S. N. Singh and R. P. S. Chauhan, *Sheila Dhar Institute of Soil Science, University of Allahabad*

Different nitrogenous compounds as calcium nitrate, ammonium nitrate and ammonium sulphate were added separately at two levels of nitrogen (0·0025% and 0·0075%) in 150 ml. of medium (as performed by Dev) containing 3 ml. of 30% cane sugar solution. After sterilization few cells of algae were inoculated and the flask were exposed to 100 watt bulb for 12 hours daily.

Analysis after 60, 120 and 180 days showed that the fixation of nitrogen was more pronounced in presence of cane sugar solution. But in presence of nitrogenous compounds the growth was faster, the nitrogen fixation was suppressed.

It has been observed that Anabaena naviculoides and Tolypothrix tenuis can grow well and fix atmospheric nitrogen in a nitrogen free medium. But chlorella vulgaris did not grow in the nitrogen free medium, indicating that this algae can not utilize elementary nitrogen for its growth. The loss of nitrogen was observed in the following decreasing order

$$(NH_4)_2SO_4 > NH_4NO_3 > Ca(NO_3)_2.$$

The maximum loss of nitrogen was observed when higher concentration of nitrogenous compounds were used.

24. Nitrogen fixation studies in the laterite soils of Kerala.

N. R. Dhar and C. K. George, *Sheila Dhar Institute of Soil Science, University of Allahabad.*

A large number of experiments were conducted in light and dark on the fixation of nitrogen in the laterite soils of Kerala with energy materials and phosphates. The results indicated a higher nitrogen status in phosphated treatments. After a period of 150 days nitrogen loss was observed in all the systems.

25. Manurial effect of water hyacinth and phosphates on the yield of paddy.

N. R. Dhar and C. K. George, *Sheila Dhar Institute of Soil Science, University of Allahabad.*

A field trial on the manurial effect of water hyacinth in crop production separately and in combination with Tata basic slag was conducted by growing paddy in the Kharif season. Fertilizer nitrogen in the form of urea and ammonium sulphate was added to some of the plots to compare the yield with that of water hyacinth plots. The results showed that on equal N basis the addition of water hyacinth produced higher yield than urea and ammonium sulphate. It was also observed that application of Tata basic slag along with water hyacinth was superior.

26. The comparative efficiency of different phosphatic fertilizers in manuring paddy.

N. R. Dhar and C. K. George, *Sheila Dhar Institute of Soil Science, University of Allahabad.*

The manurial efficiency of super-phosphate, rock phosphate and German basic slag were compared on the yield of paddy in laterite and 'Kole' soils of Kerala The phosphatic fertilizers were added at the rate of 30 lbs. P_2O_5 per acre. Nitrogen and potash were supplied at the same rate to all the plots. It was observed that maximum yield was observed by the application of German basic slag in both soils.

27. Studies in composting—Effect of coal phosphates and nitrogenous materials.

N. R. Dhar, C. K. George and A. K. Sen, *Sheila Dhar Institute of Soil Science, University of Allahabad.*

Composting experiments using mixed leaves, coal, phosphates and nitrogenous materials were conducted to find their relative efficiency in composting. The treatments containing phosphates fixed more nitrogen while the addition of nitrogenous materials showed a decrease in total nitrogen. The nitrogen loss was more marked in treatments where nitrogenous materials were added in the form of fertilizers.

28. Role of soil testing and use of urea for paddy in W. Bengal.

S. K. Ghosh, *Fertilizer Corporation Limited Durgapur (West Bengal).*

It has been found from the experiments conducted in West Bengal over a wide range of climate and soil conditions varying from saline, laterite and sandy loam to clays on the efficiency of different sources of nitrogen in increasing the yield of paddy that urea is as good a source of nitrogen for this crop as any other nitrogenous fertiliser. Urea, being the cheapest source of nitrogen on per unit basis, can easily replace other forms of nitrogenous fertiliser for paddy. Foliar application of urea has been found to be superior than soil application.

Response of crop yield to the application of nitrogenous fertiliser depends upon soil moisture situation and physico-chemical nature of the soil and has a good correlation. Necessity of soil testing before the application of fertiliser has been emphasised. This is important, more so, due to recent introduction of high yielding paddy varieties.

29. Amperometric Determination of Copper as Copper Benzidine Thiocyanate Complex.

A. L. J. Rao and B. K. Puri, *Department of Chemistry, Punjabi University. Patiala*

An amperometric procedure has been described for the determination of copper as copper benzidine thiocyanate complex in 0·2 M ammonium acetate and 0.01% gelatin at −0·4 V versus S. C. E. L and reversed L. Shaped curve are obtained in direct and reverse titration respectively.

TABLE I

Effect of pH

Copper solution taken in ml.	Copper taken in mg.	pH	Copper found in mg.
2·00	3·1780	5·90	3·1780
2·00	3·1780	5·40	3·1780
2·00	3·1780	5·20	3·1780
2·00	3·1780	4·80	3·1780
2·00	3·1780	4·40	1·2710
2·00	3·1780	4·00	—

TABLE II

Amperometric Determination of Copper

Direct Titration

Ammonium Acetate = 0·2 M
Gelatin = 0·01 %
pH = 5·4
Sensitivity = 1/200

Volume of copper nitrate taken in ml.	Amount of copper taken in mg.	Volume of 0·2 N potassium thiocyanate used from graph in ml.	Copper found in mg.
2·00	3·1780	0·50	3·1780
2·40	3·8136	0·60	3·8130
3·60	5·7204	0·90	5·7 90
4·40	6·9916	1·10	6·9900
4·80	7·6272	1·20	7·6250
5·20	8·2628	1·30	8·2580

TABLE III

Reverse Titration

Volume of 0·05 N Potassium thiocyanate taken in ml.	Amount of copper taken	Volume of copper nitrate used from graph in ml.	Copper found in mg.
1·60	2·5425	0·40	2·5420
2·20	3·4958	0·55	3·4940
2·60	4·1314	0·65	4·1300
3·00	4·7670	0·75	4·7650
5·00	7·9450	1·25	7·4930
6·00	9·5340	1·50	9·5300

30. On $W_{k,\mu}(x)$ and G-Functions

R. N. PANDEY AND V. M. PANDE, *Institute of Technology, Banaras Hindu University*

In this note, we define a transform which happens to be generalisation of Stieltjes and Hankel transforms. An inversion formula with few theorems are deduced.

An inversion formula is given as

$$f(x) = \frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} x^{t+1}\,\frac{M(t)}{\psi(t)}\,dt, \qquad \ldots\ldots t = c + ir$$

where
$$\psi(t) = -\frac{(2\pi)^{3/2}(1-n_2)\cdot n_2^{\,l-k-t-\frac{1}{2}}\,\alpha^{t+2}}{\Gamma(\frac{1}{2}+\mu-k)\,\Gamma(\frac{1}{2}-\mu-k\,(a^{n_1/n_2})\,2(t+2)} \times$$

$$G^{m+2n_2,\,n+n}_{p+2n_2,\,q+n_2}\left(\left[\frac{\alpha n_2}{a^{n_1/n_2}}\right]^{n_2}\middle|\begin{matrix}\Delta n_2[-n_2;\ l-\mu+t-n_2+\frac{7}{2}],\ \Delta n_2[-n_2;\ \mu+l+t-n_2+\frac{7}{2}],\ (ap)\\ \Delta[n_2;\ t-k-l+2]\ (b_q)\end{matrix}\right),$$

provided that the following conditions are satisfied,

(*i*) $0 \leqslant m \leqslant q,\ 1 \leqslant n \leqslant p < q,\ R[t+\frac{5}{2}+n_2 b_j+l-\mu]>0, \qquad j = 1, \ldots, m,$

(*ii*) $R[t+\frac{5}{2}+nb_j+l+\mu]>0, \qquad j = 1, \ldots, m,$

and (*iii*) $R[t+1+n_2 a_j-n_2 \max\{1,(k+l+1)\}]<0, \qquad j = 1, \ldots, n.$

31. On G and H Functions

V. M. PANDEY AND R. N. PANDEY, *Institute of Technology, Banaras Hindu University*

In this paper, we have given a new generalisation of Meijer Stieltjes and Hankel transforms.

An inversion formula is given as,

$$f(t) = \frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} t^{\xi}\,\frac{M(\xi)}{\psi(\xi)}\,d\xi, \qquad t = c + ir$$

where $\psi(\xi) =$

$$a^{-\xi-1}\,H^{m+f,\,k+n}_{p+l,\,q+r}\left[\frac{z}{a^{\sigma}}\,\middle|\,\begin{matrix}\{(a_n,\alpha_n)\},\ \{(-d_l-\xi,\sigma)\}\ (a_{n+1},\alpha_{n+1}),\ \ldots\ldots\ (a_p,\alpha_p)\\ \{(b_m,\beta_m)\},\ \{(-c_n-\xi,\sigma)\},\ (b_{m+1},\beta_{n+1})\ \ldots\ldots\ (b_q,\beta_q)\end{matrix}\right],$$

provided that the following conditions are satisfied,

$$R[\xi-1+(c_j-1)+\sigma\left(\frac{a_{h'}-1}{\alpha_{n'}}\right)< 0,\ (j = 1, \ldots f,\ h'=1, \ldots n),\ \sigma>0,$$

$$R\,[\xi-1+\sigma\left(\frac{b_h}{\beta_h}\right)+d_i]>0,\ (h=1, \ldots\ldots m,\ i=1, k)$$

$$\sum_1^n \alpha_j - \sum_{n+1}^{p}\alpha_j + \sum_1^m \beta_j - \sum_{m+1}^{q}\beta_j \equiv \lambda > 0,\ 2k+2f-l-r \equiv \mu>0,$$

$$|\arg z| < \tfrac{1}{2}\lambda\pi, \text{ and } |\arg a| < \tfrac{1}{2}\mu\pi.$$

Here uniqueness theorem and some examples are derived.

32. Studies on the effect of some agro-chemicals on nitrogen transformations in soil—1. Nitrate Nitrogen Carrier.

S. P. Jaiswal, *Sugar Cane Research Station, Jullunder Cantt.*

Effect of telodrin and gamma isomer of benzene hexachloride on transformations of soil and fertilizer nitrogen under two moisture regimes have been investigated. These pesticides were found to accelerate the accumulation of available nitrogen interlocked in soil organic matter probably by increasing the activity of micro organisms responsible for mineralization of soil organic matter. Telodrin at higher rate of application also favoured accumulation of ammoniacal nitrogen. With the addition of fertilizer nitrogen in the form of sodium nitrate gradual loss of nitrogen was noticed which was suppressed to a great extent with the pesticidal treatments.

33. Some theorems on a transform whose kernel contains $M_{k,\mu}(x)$, G-Functions

V. M. Pandey and R. N. Pandey, *Institute of Technology, Banaras Hindu University*

In this paper we have given a new transform whose kernel contains Whittaker and Meijer's G-functions.

An inversion formula of the transform has been defined as :

$$f(x) = \frac{1}{2\pi i}\int_{c+1-i\infty}^{c+1+i\infty} x^{t+1}\frac{M(t)}{\psi(t)}\,dt, \qquad t = c+ir$$

where $\psi(t) = \dfrac{\Gamma(2\mu+1)}{\Gamma(\frac{1}{2}+k+\mu)}\dfrac{a^{t+2}}{(a^{n_1}/n_2)^{2(t+2)}}\left[-(2\pi)^{\frac{1}{2}(1-n_2)}\, n_2^{(l+k-t-3/2)}\right]\times$

$$G^{m+2n_2,\,n}_{p+2n_2,\,q+n_2}\left(\left[\frac{\alpha n_2}{a^{n_1}/n_2}\right]^{n_2}\;\middle|\;\begin{matrix}\Delta n_2[-n_2;\ 7/2+l+\mu+t-n_2],\ (a_p),\ \Delta[n_2;\ t+\mu-l+5/2]\\ \Delta\,[\,n_2;\ k-l+t+2],\qquad\qquad (b_q)\end{matrix}\right),$$

provided that (*i*) $0\leqslant m\leqslant q,\ 1\leqslant n\leqslant p<q,$

(*ii*) $R[t+5/2+n_2b_j+l+\mu]>0,\ j=1,\ \ldots.\ m,$ and

(*iii*) $R[t+1+n_2\,a_i-n_2+\max\{1,\ 1-k+l\}]<0,\ i=1,\ \ldots.\ n.$

A few theorems have been deduced and an example has been obtained.

34. Colorimetric studies on the interaction of Lewis acids with p-bromophenacylidene p-dimethyl amino aniline.

D. R. Gupta and C. L. Taploo, *Department of Chemistry, U. P. Agricultural University, Pantnagar (Nainital).*

p-Bromo phenacylidene p-dimethyl amino aniline has been used as a chelating agent for Ag(I), Cd(II), As(III) and Zr(IV). The composition of the chelates has been determined by spectrophotometric studies and it has been found that the chelation takes place through the carbonyl and azomethine groups of the anil.

35. Some axisymmetric mixed boundary value problems of steady state heat conduction in a cylinder.

H. C. CHATURVEDI, *Department of Applied Mathematics, S. A. T. I. Vidisha (M. P.).*

The formal solution of axisymmetric steady state conduction problem for a finite cylinder is given ; some part ($o \leqslant \phi \leqslant 2\pi$; $o < e \leqslant a$) of the plane $z = +l$ and $z = -l$ are at prescribed temperature $f(e)$ while the rest ($o \leqslant \phi \leqslant 2\pi$; $a \leqslant e \leqslant 1$) of the plane is insulated against the flow of heat across it and from the lateral surface ($e^2 = x^2 + y^2 = 1$, $-e \leqslant z \leqslant l$) of the cylinder there is radiation into medium at zero temperature The problem is formed in terms of dual series equations and the solution of these equations is reduced to that of solving a Fredholm integral equation of second kind, which, in general, is solvable numerically. Application of the solution, of dual series equations, derived here is shown in two problems of steady state heat conduction. These problems deal separately with infinite and finite cylinders. In the case of the finite cylinder plane $z = l$ is insulated against the flow of heat across it. In both these problems mixed boundary conditions on the plane $z = o$ are similar to those prescribed on the plane $z = l$ in the original problem.

36. On J_ν and G-Functions

R. N. PANDEY AND V. M. PANDEY, *Institute of Technology, Banaras Hindu University.*

In this paper, we have defined a new transform which is generalisation of Hankel and other transforms.

The Kernel of the transform contains bessel function of first kind of order ν and H-function defined by Fox C.

An inversion formula for the transform is

$$f(x) = \frac{1}{2\pi i}\int_{1+c-i\infty}^{1+c+i\infty} x^{t+1}\frac{M(t)}{\psi(t)}\,dt, \qquad t = c+i\tau$$

where $$\psi(t) = a^{s-l-1}\, G^{m,\,n+1}_{p+2,\,q}\left(\frac{a}{\alpha}\,\middle|\, \begin{matrix} -t-l-\frac{1}{2}\nu,\ a_1 \ldots a_p,\ -t-l+\frac{1}{2}\nu \\ b_1 \ldots b_q \end{matrix}\right),$$

provided that

$$(p+q) < 2(m+n),\ |\arg a| - |\arg \alpha| < (m+n-\tfrac{1}{2}p-\tfrac{1}{2}q)\pi,$$

and $$-\tfrac{3}{4} + \max_{1\leqslant i\leqslant n} R(a_i) < R(-t-l) < 1 + \tfrac{1}{2}R(\nu) + \min_{1\leqslant i\leqslant m} R(b_i)$$

Some theorems have been obtained and an example based on transforms has been solved.

37. On some relations involving H-Functions to other orthogonal polynomials.

MANILAL SHAH, *Department of Mathematics, P. M. B. G. College, Indore (M. P.).*

In this paper the integral involving H-Function and Jacobi orthogonal polynomial has been evaluated. This integral has been employed to establish the expansion formula for H-function. A number of perticular interesting results have been also given with proper choice of parameters.

38. Some results of generalized Hypergeometric Polynomial and Bessel Functions with their applications—II

MANILAL SHAH, *Department of Mathematics, P. M. B. G. College, Indore (M. P.)*

The object of this paper is to obtain certain results involving Bessel Functions and Generalized Hypergeometric polynomial by defining the polynomial in the form

$$F_n(x) = x^{(m-1)n}\, {}_{p+m}F_q\left[\begin{matrix}\Delta(m,-n),\ a_1,\ \ldots,\ a_p \\ b_1,\ \ldots,\ b_q\end{matrix};\ Kx^c\right]$$

where the symbol $\Delta(m, -n)$, stands for the set of parameters :

$$\frac{-n}{m},\ \frac{-n+1}{m},\ \ldots\ldots,\ \frac{-n+m-1}{m},$$

and m, n are positive integers.

The polynomial is in a generalized form which yields many known polynomials on specializing the parameters. Special cases have been also given.

39. On certain recurrence relations

MRS. ARUNA SRIVASTAVA AND K. C. GUPTA, *M. R. Engineering College, Jaipur*

In this paper first we establish six recurrence relations for the H-function with the help of certain formulae concerning generalized Hankel-Transform. Later on we obtain recurrence relations for Meijer's G-function ; Gauss's hypergeometric function and Bessel function. On account of most general character of the H-function, recurrence relations for other special functions occurring in Physics and applied Mathematics can also be obtained as special cases of our results.

One of the results obtained in this paper is given below :

$$(a_p-\mu a_1)\, H^{m+1,\,n}_{p+1,\,q+1}\left[x\,\middle|\begin{matrix}(1+a_1,\sigma),\ (a_2,\alpha_2),\ \ldots,\ (a_{p-1},\alpha_{p-1}),\ (1+a_p,\mu\sigma),\ (a_1+\nu,\sigma) \\ (1+a_1+\nu,\sigma),\ (b_1,\beta_1),\ \ldots,\ (b_q,\beta_q)\end{matrix}\right]$$

$$= \nu\, H^{m,\,n}_{p,\,q}\left[x\,\middle|\begin{matrix}(1+a_1,\sigma),\ (a_2,\alpha_2),\ \ldots,\ (a_{p-1},\alpha_{p-1}),\ (a_p,\mu\sigma) \\ (b_1,\beta_1),\ \ldots,\ (b_q,\beta_q)\end{matrix}\right] +$$

$$(\nu\mu-a_p+\mu a_1)\, H^{m,\,n}_{p,\,q}\left[x\,\middle|\begin{matrix}(a_1,\sigma),\ (a_2,\alpha_2),\ \ldots\ (a_{p-1},\alpha_{p-1}),\ (1+a_p,\mu\sigma) \\ (b_1,\beta_1),\ \ldots\ (b_q,\beta_q)\end{matrix}\right]$$

where $1 \leqslant n \leqslant p-1$, $\mu > 0$.

40. Integrals involving generalised Hypergeometric Polynomials and their applications

MANILAL SHAH, *Department of Mathematics, P. M. B. G. College, Indore, (M.P.)*

The object of this paper is to evaluate certain integrals involving generalised hypergeometric polynomials by defining the polynomial in the form

$$F_n(x) = x^{(m-1)n}\, {}_{p+m}F_q\left[\begin{matrix}\Delta(m,-n),\ a_1,\ \ldots,\ a_p \\ b_1,\ \ldots,\ b_q\end{matrix};\ \mu x^c\right]$$

where m and n are positive integers and $\Delta(m, -n)$, represents the set of m-parameters :

$$\frac{-n}{m}, \frac{-n+1}{m}, \ldots\ldots, \frac{-n+m-1}{m}.$$

These integrals have been employed to establish the expansion formulae for generalised hypergeometric polynomials. Particular case have been also given with proper choice of parameters.

41. Some theorems on Fractional integration

K. C. Gupta and S. L. Mathur, *M. R. Engineering College, Jaipur and Govt. College, Nathdwara*

In this paper we establish three theorems concerning Riemann-Liouville (fractional) ; Weyl (fractional) integrals and integral transforms whose kernels are Meijer's G-function, Gauss's hypergeometric function and Modified Bessel function. Fractional integrals for Fox's H-function have been obtained by way of application of the theorems, one of them is as follows :

$$W_\mu\{t^\rho H^{m,n}_{r,q}\left[zt^\sigma \,\middle|\, \begin{matrix}(a_1, \alpha_1), \ldots\ldots, (a_r, \alpha_r)\\ (b_1, \beta_1), \ldots\ldots, (b_q, \beta_q)\end{matrix}\right]; p\}$$

$$= p^{\mu+\rho} H^{m+1,n}_{r+1,q+1}\left[zp^\sigma \,\middle|\, \begin{matrix}(a_1, \alpha_1), \ldots\ldots, (a_r, \alpha_r), (-\rho, \sigma)\\ (-\mu-\rho, \sigma), (b_1, \beta_1), \ldots\ldots, (b_q, \beta_q)\end{matrix}\right]$$

where $R(\mu)>0$, $\sigma>0$, $R\{\rho+\sigma(\frac{a_j-1}{\alpha_j}) + \mu\}<0$

$$(j=1, \ldots\ldots, n), A = \sum_1^n(\alpha_j) - \sum_{n+1}^r(\alpha_j) + \sum_1^m(\beta_j) - \sum_{m+1}^q(\beta_j)>0$$

$$\arg z < \tfrac{1}{2} A\pi \text{ and}$$

$$W_\mu\{f(t) ; p\} = \frac{1}{\Gamma(\mu)}\int_p^\infty f(t)\ (t-p)^{\mu-1}\, dt.$$

42. Determination of some organic acid by alkaline potassium permanganate using potentiometric methods.

S. Bose, *Dept. of Post-Graduate Studies and Research in Chemistry, University of Jabalpur.*

A potentiometric method is described for the determination of small quantities of organic acids (saturated and unsaturated) by oxidising with excess alkaline permanganate using barium chloride to precipitate barium manganate at the equivalence point. The excess of the oxidant was determined by titrating with standard mandelic acid solution. Mandelic acid is directly titrated potentiometrically by adding it slowly to the beaker containing the alkaline permanganate and barium chloride where as formic, pyruvic, lactic and acrylic acids are kept with excess oxidant for 24 hours at room temperature. Mandelic acid is oxidised to benzoic acid and pyruvic. lactic and acrylic acids to oxalic acid. These oxidation products were isolated and estimated. Formic acid is oxidised completely to carbondioxide and water.

43. Maximum Error of the Hermite's Interpolating polynomial.

R. K. JAIN, *Department of Mathematics, Birla Institute of Technology and Science, Pilan (Rajasthan).*

Maximum Error of the Hermite's Interpolating polynomial is derived by using chebyshev's theorem and the error formula for the Hermite's interpolating polynomial.

44. Some results for generalized Hypergeometric functions.

G. S. OLKHA AND P. N. RATHIE, *Department of Mathematics, M. R. Engineering College, Jaipur.*

The object of this paper is to sum up certain infinite series involving products of Fox's H-function and hypergeometric function ${}_4F_3$, Fox's H-function and ${}_6F_5$, Appell's function F_4 and Laurecella's hypergeometric function F_C and confluent hypergeometric function and F_4 respectively. A number of interesting special cases involving Wright's generalized hypergeometic function $p\ q$, Meijer's G-function, Gauss's hypergeometric function ${}_2F_1$ etc. have been derived. One of the results obtained in this paper is given here:

$$H^{m+2,\ l+1}_{p+4,\ q+2}\left[za^{-\delta}\ \middle|\ \begin{matrix}\{(a_l, e_l)\},\ (\frac{1}{4}-\frac{\sigma}{2}-\frac{\lambda}{2}-\frac{\delta}{2}),\ (\frac{1}{4}-\frac{\sigma}{2}-\frac{\lambda}{2}+\mu, \frac{\delta}{2}),\ (\frac{1}{4}-\frac{\sigma}{2}-\frac{\lambda}{2}+\nu, \frac{\delta}{2}), \\ \{(b_m, f_m)\},\ \frac{\mu}{2}+\frac{\nu}{2}-\frac{\sigma}{2}-\frac{\lambda}{2}-\frac{1}{4}, \frac{\delta}{2}), \\ (\frac{1}{4}-\frac{\sigma}{2}-\frac{\lambda}{2}+\mu+\nu,\ \frac{\delta}{2}),\ (a_{l+1}, e_{l+1}), \ldots, (a_j, e_j) \\ (\frac{\mu}{2}+\frac{\nu}{2}+\frac{1}{4}-\frac{\sigma}{2}-\frac{\lambda}{2}, \frac{\delta}{2}),\ b_{m+1}, f_{m+1}), \ldots, (b_q, f_q)\end{matrix}\right]$$

$$= \sum_{n=0}^{\infty} \frac{\pi\, \frac{1}{2}2^{\delta-\mu-\nu+\sigma+3/2}\ (a/c)^{\lambda+\sigma+3/2}\ (\lambda+2n)\,\Gamma(\lambda+n)}{n!\ \Gamma(\mu+1)\ \Gamma(\nu+1)}$$

$${}_4F_3\left[\frac{-n,\ \lambda+n, \frac{\mu+\nu+1}{2}, \frac{\mu+\nu+2}{2}, \frac{4a^2}{c^2}}{\mu+1,\ \gamma+1,\ \mu+\nu+1}\right] \times$$

$$\times\ H^{m,\ l+1}_{p+2,\ q}\left[z\,(2/c)^{\delta}\ \middle|\ (\tfrac{1}{4}-\tfrac{\sigma}{2}-\tfrac{\lambda}{2}-n, \tfrac{\delta}{2}),\ \begin{matrix}\{(a_j, e_{2j})\}, \\ \{(b_q, f_q)\}\end{matrix}\ (\tfrac{1}{4}-\tfrac{\sigma}{2}+\tfrac{\lambda}{2}+n, \tfrac{\delta}{2})\right]$$

provided that

$$\lambda \equiv \sum_{1}^{\rho} e_j - \sum_{l+1}^{p} e_j + \sum_{1}^{m} f_j - \sum_{m+1}^{q} f_j > 0\ ,\ |\arg z| < \tfrac{1}{2}(\lambda\pi),$$

$$R\left[\lambda + \sigma + \tfrac{3}{2} + \delta \min\,(b_j/f_j)\right] > 0\ (j=1, \ldots, m),$$

$$R\left[\sigma + \delta \max\,(a_j-1)/e_j\right] < 0 \text{ or } R\,(\mu + \nu - \lambda + \tfrac{1}{2})\ (j=1, \ldots, l).$$

45. Ordinals and Cardinals.

P. SINGH, *Deptt. of Mathematics, Ranchi College.*

This paper is devoted to a study of the concepts of ordinals and cardinals. Two approaches one of von Neumann and the other of Cantor have been disussed and then a criticism relating to the definitions of these concepts advanced. Thus the paper concerns itself with a foundational problem.

46. Integrals involving products of generalized Hypergeometric Function and Fox's H-function.

K. C. Gupta and G. S. Olkha, *M. R. Engineering College, Jaipur.*

In this paper we evaluate six integrals involving products of generalized hypergeometric function ${}_pF_q(x)$ and the H-function of Fox. Interesting integrals involving products of Bassel functions. Confluent hypergeometric functions with Meijer's G-function have been obtained as special cases of our main integrals. One of the integrals obtained in this paper is given below :

$$\int_0^1 x^{\rho-1}(1-x)^{\sigma-1}\,{}_rF_s(c_1, \ldots, c_r; d_1, \ldots, d_s; ax^k)\, H_{p,q}^{m,n}\left[zx^\lambda \,\middle|\, \begin{matrix}\{(a_p, \alpha_p)\}\\ \{(b_q, \beta_q)\}\end{matrix}\right] dx$$

$$= \sum_{r=0}^{\infty} \frac{\prod_1^r (c_j)_\nu\, a^\nu\, \Gamma(\sigma)}{\prod_1^s (d_j)_\nu\, \nu!}\, H_{p+2k+1,\, q+2k+1}^{m,\, n+2k+1}\left[z \,\middle|\, \begin{matrix}(1-\rho,\lambda),\ \{\Delta(k,\ 1-\rho-\nu k),\ \frac{\lambda}{k}\},\\ \{(b_q,\beta_q)\},\ \{\Delta(k, 1-\rho),\ \frac{\lambda}{k}\},\end{matrix}\right.$$

$$\left.\begin{matrix}\{\Delta(k,\ 1-\rho-\sigma),\ \frac{\lambda}{k}\},\ \{(a_p,\ \alpha_p)\}\\ \{\Delta(k,\ 1-\rho-\sigma-\nu k),\ \frac{\lambda}{k}\},\ (1-\rho-\sigma-\lambda)\end{matrix}\right]$$

where $R(\rho) > 0$, $R(\sigma) > 0$, k is a positive integer, $\lambda > 0$

$A = \sum_1^n (a_j) - \sum_{n+1}^p (\alpha_j) + \sum_1^m (\beta_j) - \sum_{m+1}^q (\beta_j) > 0$, $|\arg z| < (\frac{1}{2} A\pi)$ and $R(\rho + (\lambda b_h)(\beta_h) > 0 \quad (h = 1, \ldots, m)$, $\{\Delta(\delta, \alpha), \lambda\}$ stands for $\left(\frac{\alpha}{\delta}, \lambda\right), \left(\frac{\alpha+1}{\delta}, \lambda\right), \ldots, \left(\frac{\alpha+\delta-1}{\delta} - \lambda\right)$.

O certain recurrence relations for Fox's H-function.

S. P. Goyal, *Department of Mathematics, M. R. Engineering College, Jaipur.*

In this paper we establish certain recurrence relations for Fox's H-function, Meijer's G-function and Gauss's hypergeometric function. On account of the most general character of the H-function, recurrence relations for various other special functions occurring in Physics and Applied Mathematics can also be obtained. Some of the results deduced in this paper are as follows :

$$H_{p,q}^{m,n}\left[x \,\middle|\, \begin{matrix}(a_1, \sigma), (a_2, \alpha_2), \ldots, (a_{p-1}, a_{p-1}), (a_p - \alpha, \sigma)\\ \left(\frac{a_p}{2} + \frac{a_1}{2} - \frac{\alpha}{2} - \frac{1}{2}, \sigma\right), \left(\frac{a_p}{2} + \frac{a_1}{2} - \frac{\alpha}{2}, \sigma\right), (b_3, \beta_3), \ldots, (b_q, \beta_q)\end{matrix}\right]$$

$$= 2^\alpha \sum_{r=0}^{\infty} \frac{(\alpha)_r}{r!}\, H_{p,q}^{m,n}\left[x \,\middle|\, \begin{matrix}(a_1 - r, \sigma), (a_2, a_2), \ldots, (a_{p-1}, \alpha_{p-1}), (a_p + r, \sigma)\\ \left(\frac{a_p}{2} + \frac{a_1}{2} - \frac{1}{2}, \sigma\right), \left(\frac{a_p}{2} + \frac{a_1}{2}, \sigma\right)(b_3, \beta_3), \ldots, (b_q, \beta_q)\end{matrix}\right]$$

where $m \geqslant 2$, $1 \leqslant n \leqslant p - 1$.

$$H^{\,m,\,n}_{\,p,\,q}\left[x\,\middle|\begin{matrix}(a_1,\sigma),(a_2,\alpha_2),\ldots,(a_{p-1},\alpha_{p-1}),(a_p-n',\sigma)\\ \left(\frac{a_p}{2}+\frac{a_1}{2}-\frac{n'}{2}-\frac{1}{2},\sigma\right),\left(\frac{a_p}{2}+\frac{a_1}{2}-\frac{n'}{2},\sigma\right),(b_3,\beta_3),\ldots,(b_q,\beta_q)\end{matrix}\right]$$

$$=\sum_{r=0}^{n'}\frac{(n')_r\,2^{n'-r}}{r!}\,H^{\,m,\,n}_{\,p,\,q}\left[x\,\middle|\begin{matrix}(a_1-r,\sigma),(a_2,\alpha_2),\ldots,(a_{p-1},\alpha_{p-1}),(a_p,\sigma)\\ \left(\frac{a_p}{2}+\frac{a_1}{2}-\frac{r}{2}-\frac{1}{2},\sigma\right),\left(\frac{a_p}{2}+\frac{a_1}{2}-\frac{r}{2},\sigma\right)(b_3\beta_3),\ldots(b_q\beta_q)\end{matrix}\right]$$

where $m \geqslant 2$, $1 \leqslant n \leqslant p-1$ and n' is a non-negative integer.

48. Internal waves of Finite Amplitude and Permanent form in presence of external force.

LALJI SINGH AND R. N. PANDEY, *Institute of Technology, Banaras Hindn University, Varanasi.*

In this paper, a theory for two dimensional waves including solitary and periodic Cnoidal waves have been obtained. The waves propagate with no change of form in a heterogeneous liquids. Here we have assumed that the velocity of the stream is in horizontal direction, whose density and velocity are arbitrary functions of vertical height, and the upper surface of the fluid is free or fixed in a horizontal plane. Further, it is assumed that an external force, $P(y)$, which is also a function of height only and such that at the upper surface the relation $ap_0/d\eta = -\rho' P(\eta)$ is satisfied. The formulae for the wave properties and the condition for their occurrence have also been derived. The general equation for periodic Cnoidal wave has been obtained in the form,

$$If\alpha^2 = Jf^2 - f^3 k + 2\,(S_d - \gamma),$$

where

$$I = \int_0^{ho} Q\,\phi_n^2\,d\eta$$

$$J = \int_0^{ho} V_n\left(\frac{d\,\phi_n}{d_n}\right)d\eta$$

$$K = \int_0^{ho} Q_n\left(\frac{d\phi_n}{d\eta}\right)^3 + \rho\,\phi^2{}_n\frac{d\phi}{d\eta}\rho''(\eta) + \tfrac{1}{2}\,\rho\,\phi^2{}_n\,\rho'''(\eta)\,d\eta$$

Sd = Disturbed flow force, where, the symbols have their usual meanings.

At the end, several examples have been worked out to show the existence of the present theory.

49. Studies in Reductions with Vanadium (II) (Potentiomatric Titration of Ce(IV) and Mn(III) with V(II)

SUKH NANDAN PRASAD, *Chemistry Department, L. S. College, Muzaffarpur* AND NARAYAN THAKUR AKINCHAN, *Chemistry Department, M. I. T. Muzaffarpur.*

Direct and reverse Potentiometric Titration of Vanadium (II) againts Mn(III) and Ce(IV) have been performed in the atmosphere of Oxygen free nitrogen using Mercury coated as indicator electrode. When V(II) is in the cell, Mn(III) and Ce(IV) oxidises it successively to V(III), V(IV) and finally to V(V). If Mn(III) or Ce(IV) is in the cell Mn(III) and Ce(IV) is reduced to Mn(II) and Ce(III) respectively and V(II) itself is oxidised to V(V), which on further addition of V(II) gives V(IV) and finally V(III).

50. Electroluminescence in ZnO–CdSe Alloy Systems

V. B. Singh and Hari Mohan, *Physics Department, Allahabhd University.*

A new series of electroluminophors of the composition ZnO CdSe: Cu, X (Cl, Br or I) has been synthesised. By varying relative proportion of the two constituents, ZnO and CdSe forming the host lattice, a number of samples giving electroluminescent emission right from green to deep red have been prepared through heat-treatment in an atmosphere of pure nitrogen.

The peak emission from the system was found to shift towards higher wavelengths as the proportion of CdSe in the solid solution is successively increased.

The effect of applied voltage and frequency on the electroluminescent output has been studied.

51. Kinetics and Mechanism of the Reduction of Peroxydisulphate by Ascorbic acid

U. S. Mehrotra, Binda Prasad and S. P. Mushran, *Chemical Laboratories, University of Allahabad*

The kinetics of the reduction of peroxydisulphate by ascorbic acid has been studied in an acidic medium. The rate of reduction has a direct dependence on the concentration of peroxydisulphate and is independent of ascorbic acid concentration. The influence of neutral salt is negligible while that of acidity is slightly retarding. Allyl acetate inhibits strongly and suggests the formation of sulphate radical ions (SO_4^-). A chain mechanism initiated by the decomposition of peroxydisulphate, has been proposed which involves the intermediate formation of hydroxyl and ascorbate free radicals. The following rate law has been derived which governs the experimental results.

$$-\frac{d}{dt}\left[S_2O_8^{2-} \right] = \left(\frac{k_{10}k_2k_4}{k_5}\right)^{\frac{1}{2}} \left[S_2O_8^{2-} \right]$$

52. Kinetics af arsenite–ferricyanide reaction in an alkaline medium.

M. C. Agrawal, V. K. Jindal and S. P. Mushran, *Department of Chemistry, University of Allahabad.*

The kinetics of the oxidation of arsenite to arsenate by ferricyanide has been studied in an alkaline medium. At low alkali concentrations the reaction is very slow and the reaction rates have therefore been determined in highly alkaline media ($OH^- > 10^{-2}M$). The overall kinetics is first order to ferricyanide, arsenite and hydroxide ions. Addition of neutral salts *viz.* KCl and K_2SO_4 has a pronounced accelerating effect. Addition of ferrocyanide has no effect while methanol considerably lowers the reaction rate. The temperature coefficient of the reaction has been found to be unusually low and therefrom the energy and entropy of activation have been obtained as 8·2 Kcals and −42·8 cal. deg^{-1} $mole^{-1}$ respectively. A mechanism has been proposed which involves the primary equilibria between various arsenite species and the hydroxide ions and is followed by the rate determining bimolecular reaction between a tribasic arsenite ion and ferricyanide.

53. On the Propagation of Plane Shock Waves in a Liquid Containing Bubbles of a Conducting Gas

B. G. VERMA, *Department of Mathematics, University of Gorakhpur*

The paper considers the propagation of plane shock waves in a mixture of conducting gas and liquid by taking appropriate equations of continuity, momentum, energy and an equation of state. When the temperature rise, which is small for a very wide range of problems, is neglected across a shock, it is shown that the shock wave relations assume a simple form. It is also suggested that the relations can be applied to the collision between two normal shock waves.

54. A Simple apparatus for the microdetermination of Ammonical and Nitrate Nitrogen through Steam Distillation.

O. P. SRIVASTAVA, *Department of Chemistry-Biochemistry, Punjab Agricultural University, Ludhiana.*

A simple apparatus for the microdetermination of ammonical and nitrate nitrogen through steam distillation has been designed. It is very rapid in function and gives reproduceable results with great accuracy. It is carefree in functioning. It is particularly very useful for determining ammonical and nitrate nitrogen in various studies of organic matter decompositon in soil and compost.

Analytical reagent grade ammonium nitrate (having 99% purity) was used for testing the apparatus. 0·2% solution of ammonium nitrate was prepared and its suitable aliquot (5 milli litre) was taken for ammonical and nitrate nitrogen determinations. Magnesium oxide was used for ammonical nitrogen liberation and Devard's alloy was used for nitrate nitrogen determination. Both the nitrogen fractions from the same aliquot were separately absorbed in boric acid solution and titrated against N/50 HCl. Recovery of ammonical and nitrate nitrogen was 98·65% and 98·7% respectively.

55. Solubility of calcium and magnesium in Indian bentonites.

S. K. DE AND S. K. SRIVASTAVA, *Department of Chemistry, University of Allahabad.*

Solubility of calcium and magnesium in three important Indian bentonites *viz.* $Kashmir_1$, $Kashmir_2$ and West Bengal had been studied in water and two important mineral acids after giving them certain preliminary treatments. The treatments were done specially to observe the effects of temperature (in range of 100°C, 400°C and 800°C), different degrees of alternate wetting and drying (till saturation) and grinding with Na_2CO_3 in different proportions and for different periods The extraction after these treatments was done with specific quantities of water and mineral acids after boiling for certain period of time.

It is pointed out that when the bentonites are to be added to soils, their efficiency so far as the ready availability of calcium and magnesium oxides are concerned may prove better if before application they are given certain preliminary treatments such as mentioned earlier.

56. Nitrogen fixation of slightly alkaline soil by the addition of different calcium salts.

S. K. De and Sharafat Ali, *Department of Chemistry, University of Allahabad.*

Addition of calcium salts *viz.* calcium carbonate, di-calcium phosphate, calcium oxide, calcium sulphate, calcium sulphite, calcium sulphide, calcium acetate and calcium citrate between 2 m.e. to 20m.e.concentrations has heen found to increase nitrogen fixation in a slightly alkaline soil. 16 m.e. concentration of calcium salts per 100 g of soil is found to give the best result. Di-calcium phosphate and calcium sulphide are found to give maximum effect in rendering an increase in the fixation of nitrogen in case of one month experimental plates and calcium citrate and calcium carbonate in case of two months experimental plates. The fixation of nitrogen was best carried out with the lowering of pH, by the addition of all calcium salts except in the case of calcium carbonate and calcium oxide.

57. A new technique of studying soil erosion in the laboratory.

Anupam Varma and S. K. De, *Department of Chemistry, University of Allahabad.*

A new technique has been evolved by the authors to study soil erosion in the laboratory. A simple apparatus has been developed for the purpose. A definite quantity of soil is packed at the saturation percentage in a one cubic inch container which is at the top of a slope base of one feet length. The soil before packing can be treated with any material of which the effect on soil erosion is to be studied. The slope base can be adjusted at any slope ranging from 0 percent to 30 percent or more. The water is dropped from a height of about 3/4 inch by a burette over the packed soil at a constant rate. The soil thus eroded travels along the one foot long slope base and is collected in a weighed beaker. The water in the beaker is evaporated and finally the weight of the eroded soil is found out. The results thus obtained have been found to be within $\pm$ 5% error from those obtained in the field.

58. Molecular constants of Tungsten Hexachloride.

Nitish K. Sanyal, H. S. Singh and A. N. Pandey, *Physics Dept., Gorakhpur University*

On the basis of available molecular dimensions and spectroscopic data, Tungsten Hexachloride was subjected to normal coordinate analysis using Wilson's F – G matrix method. Molecular constants like force constants, mean amplitudes of vibration and Bastiansen-Marino shrinkages have been computed. The results obtained have been discussed.

59. Orbital Valence force field constant of some X Y_4 type ions.

Nitish K. Sanyal, A. N. Pandey and H. S. Singh, *Physics Dept., Gorakhpur University.*

Orbital valence force field has been applied to the case of four tetrahedral oxoanions of IV Group. A complete set of force constants have been evaluated. The results of OVVF calculations have been compared with the force constants obtained using Urey Bradley force field and Lennard Jones potential approximation.

60. Precipitation of some Metal Hydroxides.

S. W. M. Subuktagin and Rameshwar Prasad, *Chemical Laboratories, Patna University.*

A preliminary study of precipitation of Cu^{2+}, Fe^{3+} and Sn^{4+} was undertaken as a part of the programme of the study of some basic salt formation by X-ray diffraction technique. It is well known that when an alkali is interacted with a metal salt solution, the amount of alkali required for the complete precipitation is always less than the theoretically equivalent amount. Copper, iron and tin were interacted with different alkalies *viz.* sodium hydroxide potassium hydroxide, ammonium hydroxide (not with copper) and sodium carbonate and none of them approached the theoretical equivalent. The precipitation values were in the following order. The suffices at metal ions shows '*d*' for the dilute solution or '*fd*' for the fairly dilute solution.

Cu^{2+}	KOH > Na_2CO_3 > NaOH
Cu^{2+} (*d*)....	KOH > NaOH > $NaCO_3$
Cu^{2+}(*fd*) ...	KOH > NaOH > $NaCO_3$
Fe^{3+}	KOH > NaOH > NH_4OH > Na_2CO_3
Fe^{3+}(*d*)	KOH > NH_4OH > NaOH > Na_2CO_3
Fe^{3+}(*fd*)....	KOH > NH_4OH > NaOH > Na_2CO_3
Sn^{4+}	NaOH > NH_4OH > Na_2CO_3 > KOH
Sn^{4+}(*d*)	NaOH > NH_4OH > KOH > Na_2CO_3
Sn^{4+}(*fd*) ...	NaOH > NH_4OH > KOH > Na_2CO_3

The behaviour of metal ions towards an alkali has been also studied separately. The order of the precipitation is as follows :

NaOH ...	Sn^{4+} > Fe^{3+} > Cu^{2+}
NaOH (*d*) ...	Sn^{4+} > Cu^{2+} > Fe^{3+}
NaOH (*fd*) ...	Sn^{4+} > Cu^{2+} > Fe^{3+}
KOH ...	Sn^{4+} > Cu^{2+} > Fe^{3+}
KOH (*d*) ...	Sn^{4+} > Cu^{2+} > Fe^{3+}
KOH (*fd*) ...	Sn^{4+} > Cu^{2+} > Fe^{3+}
Na_2CO_3 ...	Sn^{4+} > Cu^{2+} > Fe^{3+}
Na_2CO_3(*d*) ...	Sn^{4+} > Cu^{2+} > Fe^{3+}
Na_2CO_3(*fd*) ...	Sn^{4+} > Cu^{2+} > Fe^{3+}

With dilute solutions the precipitation values approach the theoretical values.

In another set of experiments, copper sulphate, ferric chloride and tin chloride solutions were put in glass tubes and sealed at both the ends. After heating these tubes at 200°C for six weeks, the resultant materials were taken out and analysed. The materials thus formed were basic metal sulphates.

61. Electronic spectrum of BaF in thermal emission.

D. P. Tewari, Janardan Singh and Hari Mohan, *Physics Department, Allahabad University.*

The electronic spectrum of Barium monofluoride molecule in thermal emission was investigated. Vibrational constants of the $F^2\Sigma \rightarrow X^2\Sigma$ and $G^2\Sigma \rightarrow X^2\Sigma$ systems were determined with a greater accuracy, additional bands involving higher vibrational quantum numbers v were obtained for $D^2\Sigma \rightarrow X^2\Sigma$ systems. An attempt was made to identify a number of new bands on the shorter wavelength in the ultraviolet region.

62. Spectra of N_2, A, air and (O_2, A) mixture excited by low energy proton bombardment

S. N. Ghosh, Y. Sahai and K. K. Bhutani, *J. K. Institute of Applied Physics and Technology, Allahabad.*

Spectra of N_2, A, air and (O_2, A) mixture were excited by bombardment of proton having energies in the range 0·56 - 1·7 kev at different target gas pressures (5–30 μ). Spectroscopic photometric and microphotometric studies were made. The excited lines and bands are identified and the relative band intensities of prominent emissions have been calculated. The spectra obtained at low energies were compared with those obtained at energies greater than 2 kav. Mechanisms for excitation of lines and bands are proposed.

63. Micro determination of some organic acids by trivalent manganese in acetic acid.

S. Bose, *Department of Post-Graduate Studies and Research in Chemistry, University of Jabalpur,*

A procedure is described for micro determination of oxalic acid, malonic acid, tartaric acid, pyruvic acid, citric acid, mandelic acid, malic acid and *p*-hydroxy benzoic acid. The method is based on oxidation of above acids by manganic acetate in 9N acetic acid. Oxalic acid oxidises to carbon dioxide and water. Malonic acid and tartaric acid oxidise to give formic acid, pyruvic acid and citric acid oxidise to give acetic acid. Malic acid oxidises and yields glycolic acid, mandelic acid oxidises to benzaldehyde and *p*-hydroxy benzonic acid oxidises to benzoquinone. These reaction products do not undergo further oxidation.

The oxidant is taken in large excess and the unused manganic acetate is determined volumetrically by iodometry. The reactions were complete at 50°C in 10 mts. However when carried out at room temperature the mixture was left overnight. The method gives reproducible results to an accuracy of $\pm$ 2%.

64. On H-function transform of two variables.

P. M. Gupta and A. B. Mathur,

Recently, Mathur and Agrawal defined a generalised transform

$$(I)\ \phi(s) = \int_0^\infty H \begin{matrix} m\ n \\ p\ q \end{matrix} \left[s\,x \middle| \begin{matrix} (a_1, \alpha_1), \ldots, (a_p, \alpha_p) \\ (b_1, \beta_1), \ldots, (b_q, \beta_q) \end{matrix} \right] f(x)\, dx$$

where kernel is the H–function of Fox. The transform (I) reduces to most of the known generalised Laplace and Hankel Transforms.

In this paper, H-Function Transform (I) has been extended to two variables as defined below :

$$(\text{II})\quad \phi(p,q) = pq\int_0^\infty\int_0^\infty H^{\,m\,n}_{r\,l}\left[px\,\middle|\,\begin{matrix}\{(a_r,\alpha_r)\}\\ \{(b_l,\beta_l)\}\end{matrix}\right] H^{m'n'}_{r'\,l'}\left[qy\,\middle|\,\begin{matrix}\{(a'_{r'},\alpha'_{r'})\}\\ \{(b'_{l'},\beta'_{l'})\}\end{matrix}\right] f(x,y)\,dx\,dy$$

for $R(p,q) > 0, |\arg p| < \frac{1}{2}\lambda\pi, |\arg q| < \frac{1}{2}\lambda'\pi,$

where $$\sum_1^n(\alpha_j) - \sum_{n+1}^r(\alpha_j) + \sum_1^m(\beta_j) - \sum_{m+1}^l(\beta_j) \equiv \lambda > 0,$$

$$\sum_1^{n'}(\alpha'_j) - \sum_{r'+1}^{r'}(\alpha'_j) + \sum_1^{m'}(\beta'_j) - \sum_{m'+1}^{l'}(\beta'_j) \equiv \lambda' > 0$$

and the double integral exists. Several properties and three theorems have been established for (II) and a few known results have been derived.

65. Representation Theorem for a generalized Laplace Transform.

G. Bihary, *Department of Mathematics, Ranchi College, Ranchi.*

In this paper a representation theorem for the generalized Laplace transform

$$P(x) = \int_0^\infty e^{-xy}(xy)^\alpha.\ L_\nu^\mu(xy)\,f(y)\,dy$$

has been given. This transform involves Laguerre function.

66. A few numerical solutions of the Lane – Emden equation of index 5.

R. S. Gupta and J. P. Sharma, *Allahabad*

Lane – Emden equation of index 5 after a few transformations and integrations can be written as

$$\frac{dz}{dt} = \pm\left[2D + \frac{z^2}{4} - \frac{z^6}{12}\right]^{\frac{1}{2}}.$$

The above equation can be integrated for finite terms for $D = 0$ and $D = 1/12$; for other r on zero values of D we resort to numerical solutions. Shambhunath and J. P. Sharma have recently given a numerical solution for $D = -0{\cdot}01$ with a view to find an approximate mass and radius of the star. In this paper similar tables for $D = -0{\cdot}02$, $-0{\cdot}03$ and $-0{\cdot}04$ have been given.

The tables of the mentioned non zero values of D show that as $|D|$ increases, dz/dt becomes imaginary with fairly large values of θ. In other words these tables do not provide values of ξ for which θ vanishes. We thus infer that numerical integrations are helpful in getting approximate mass and radius of the star corresponding to values of D lying between 0 and $-0{\cdot}01$ only. These tables also give values of θ and $\frac{d\theta}{d\xi}$ at different points in the configuration.

67. Thermal emission spectrum of new Diatom-AlSe.

JANARDAN SINGH, D. P. TEWARI AND HARI MOHAN, *Physics Department, Allahabad University.*

Electronic band spectrum due to an hitherto unidentified diatomic emitter AlSe has been observed in thermal emission from a King's type vacuum graphite tube furnace. The new spectrum which lies in the spectral range $\lambda\lambda$ 3900–4610 is characterised by well-marked red-dagraded bands and bears close resemblence with the band spectrum of AlS molecule.

Vibrational assignments of the various bands which have been grouped into one band system, presumably involving $A^2\Sigma \rightarrow X^2\Sigma$ transition, have been made and viberational constants determined.

68. Thermodynamic stability of solubilized solutions Part—1.

BHAGWAN SWAROOP, *Department of Chemistry, University of Lucknow.*

McBain in this classical work on solubilized state, mentioned that it is thermodynamically stable. In these series of papers Stability of solubilized solution has been discussed by Statistical Thermodynamics by studying the conductivity measurements starting from very dilute solution having two and three components.

69. A note on Eddington's standard model.

SHAMBHUNATH SRIVASTAVA, *Mathematics Dept., University of Allahabad.*

The model of a gaseous star in radiative equilibrium, in which the ratio of the gas pressure to the total pressure is constant, is known as Eddington's standard model. Since Eddington's time it has been believed that in such models we can assume absorption coefficient and rate of generation of energy as functions of ρ and T. Believing this, Eddington made a further assumption that

$$k\eta = \text{const.}\,; \quad \eta = \frac{\varepsilon\,(r)}{\rho_g}$$

and gave a perfectly definite distribution of density and temperature. Stromgren used the perturbation theory to apply the results based on $k\eta$ = constant to cases where $k\eta$ show slight variation from constancy. Chandrashekhar modified Stromgrren's version in "Stellar Structure".

In the present paper it has been shown that in Eddington's model, if we assume an arbitrary dependence of k and ε on ρ and T, then the solutions obtained will be inconsistent with our fundamental equation of equilibrium. In standard model k and ε must necessarily be constant. That is, the question of applying the results of the case $k\eta$ = canstant to cases where $k\eta$ show slight variation from constancy, as Stromgren and Chandrashekhar did, does not arise. It has further been shown that the total value of the luminosity of such a model is independent of mass and radius of the configuration.

70. Mechanism of oxidation of simple organic molecules Part—XVII, Oxidation of formaldehyde, acetaldehyde, propionaldehyde and Iso-butyraldehyde by bromate ion in acid media.

Miss Vibha Avasthi and A. C. Chatterji.

A kinetic study of the oxidation of formaldehyde, acetaldehyde, propionaldehyde and iso-butyraldehyde by bromate ion in presence of perchloric acid solution, at constant ionic strength of 0·4, has been made. The order with respect to aldehyde, bromate ion and hydrogen ion has been found to be one, one and one at the hydrogen ion concentrations between 0·05 to 0·477. The reaction is a bimolecular reaction if hydrogen ion is not taken into consideration.

The effect of different salts on the velocity of reaction has been studied. The salts do not appear to have any appreciable effect on the velocity of reaction although magnesium sulfate, manganous sulfate, cobalt sulfate and ammonium molybdate seemed to have a slightly depressing effect between 6 to 7%. The product of oxidation has been identified to be formic acid in the case of formaldehyde. The rate of oxidation increases with the substitution of hydrogen by methyl group in the acetaldehyde molecule.

71. On Certain Convolution Transforms

Jamuna Prasad Ambasht, *Head of the Department of Mathematics, S. P. Jain College, Sasaram (Bihar)*

If we follow the standard representation to denote a bilateral Laplace Transform as

$$\text{bi-Lap.}\left\{f(t)\ ;\ s\right\} = \int_{-\infty}^{\infty} \exp.\ (-st)\, f(t)\ dt,$$

then, our first result is

$$\text{bi - Lap.}\left[\left\{\frac{1}{\pi}\int_0^{\infty} \cos(ut)\ \text{sech}(\pi u)\ du\right\}\ ;\ s\right] = \sec\ (\pi s)$$

Our second result is

$$f(x) = \left\{\frac{1}{\pi}\int_0^{\infty} \cos(xt)\ \text{sech}(\pi t)\ dt\right\} * \phi(x) = \frac{1}{\pi}\int_{-\infty}^{\infty} \frac{\phi(t)\ e^{x+t}}{e^{2t}+e^{t}}\ dt$$

and this goes into the Stieltjes Transform

$$F(x) = \int_0^{\infty} \frac{\Phi(t)}{x+t}\ dt$$

where

$$f(x) = \exp.\ (x/2)\ F(\exp.\ x)$$

$$\phi(x) = \pi\ \exp.(x/2)\ \Phi(\exp.\ x)$$

The investigations are based on known results in Convolution Transform (Lebesgue), and a result of Ramanujan (H. T. F. (1953) ; pp. 11, eq.(27)).

72. *m* Neighborhood space.

R. N. LAL, *Department of Mathematics, Bhagalpur University.*

The paper proposes to study a space more general than DOICINOV' stopological space (Sovt. Math. 5 (1964) 595-98) w. r. t. a collection of subsets of a set the socalled a *m* nhd space in which a nhd of a set in *m* is not a nhd of a nhd of the set. In such a space, the author has introduced the notions of :

(i) *m* open sets and *m* closed sets.

(ii) *m* interior and *m* closu e operations for characterzing *m* topoloids (collection of nhd systems of each set in *m*) in a set.

(iii) Continuity of a map with its characterizations.

73. On the theory of concave transmission grating.

K. MAJUMDAR, *Physics Department, University of Allahabad.*

From simple considerations it has been shown that a concave transmission grating has focal properties and as such it can be used for production of spectra without the use of lenses and mirrors. The focal curves, which are not similar to those of a reflecting grating, have been studied in some particular cases and possible mountings discussed. It appears that such a grating will have enormous scope for study of spectra in the visible and all longer wavelength regions.

74. On the use of a single thin lens in plane grating spectrograph.

MAHIPAL SINGH AND K. MAJUMDAR, *Physics Department, Allahabad University.*

Various spects of the use of a single thin lens in a plane grating spectrograph, employing a perfectly collimated beam of incident light, have been investigated. The nature of focal curves for two typical lens materials has been studied. Expressions and numerical values for the radius of curvature, dispersion and spectrum inclination at different wavelengths in the first and in the second order of the spectrum, have been obtained. These data will be useful for the construction of a plane grating spectrograph, with low cost and fairly good achievements.

75. On axial achromatism of a combination of lenses.

MAHIPAL SINGH, *Physics Department, Allahabad University.*

Conditions for perfect axial achromatism of a combination of two lenses separated by a distance have been discussed. The results of analysis have been applied to the various aspects, for the construction of the achromatic system.

76. Synthesis of natural products related to isocoumarin system.

J. N. CHATERJEE, C. BHAKTA AND J. MUKERJI, *Department of Chemistry, Patna University.*

The synthesis of (±) 5-Methyl mallein and (±) 0-methyl ether of reticulol are described.

The synthesis of naturally occurring isocoumarin Oosponol have been tried. The diazoketone obtained from the intermediate 8-methoxy isocoumarin-4-carboxylic acid has been shown to contain four nitrogen atoms owing to the interaction of diazomethane at the 3-position of the molecule. However 0-methyl ether of oosponol acetate appears to have been obtained from 8-methoxy-4-acetyl isocoumarin by subsequent bromination and solvolysis. Diazomethane reacts in the same way with isocoumarin-4-carboxylic acid also. But in the case of isocoumarin-3-carboxylic acid, diazomethane does not show this abnormal behaviour and 3-(w-hydroxyacetyl) and 3-(w-acetoxyacetyl) isocoumarins have been successfully isolated and characterised.

77. On H-Function of two Variables

R. D. AGARWAL AND A. B. MATHUR, *Deptt. of Mathematics, S. A. T. I. Vidisha, M. P.*

While studying H-transform of two variables, authors can across many results which can be expressed and discussed in a very general way if we define H-function of two variables. Thus the H-function of two variables is defined as :

$$H^{m,n,m_1,m_2,\nu_1,\nu_2}_{p,t,s,q}\left[\begin{array}{c|l} x & (\varepsilon_p,\ e_p) \\ & (\gamma_t,\ c_t),\ (\gamma'_t,\ c'_t) \\ y & (\delta_s,\ d_s) \\ & (\beta_q,\ b_q),\ (\beta'_q,\ b'_q) \end{array}\right]$$

$$= -\frac{1}{4\pi^2}\int_{-i\infty}^{i\infty}\int_{-i\infty}^{i\infty} \phi(\xi+\eta)\ \psi(\xi,\eta)\ x^{\xi}\ y^{\eta}\ d\xi\ d\eta$$

where

$$\psi(\xi,\eta) = \frac{\prod_{j=1}^{m_1}\Gamma(\beta_j - b_j\xi)\ \prod_{j=1}^{m_2}\Gamma(\beta'_j - b'_j\eta)\ \prod_{j=1}^{\nu_1}\Gamma(\gamma_j + c_j\xi)\ \prod_{j=1}^{\nu_2}\Gamma(\gamma'_j + c'_j\eta)}{\prod_{j=n_1+1}^{p}\Gamma(1-\beta_j + b_j\xi)\ \prod_{j=m_2+1}^{q}\Gamma(1-\beta'_j + b'_j\eta)\ \prod_{j=\nu_1+1}^{t}\Gamma(1-\gamma_j - c_j\xi)\ \prod_{j=\nu_2+1}^{t}\Gamma(1-\gamma'_j - c'_j\eta)}$$

$$\phi(\xi+\eta) = \frac{\prod_{j=1}^{n}\Gamma(1-\varepsilon_j + e_j\xi + e_j\eta)}{\prod_{j=n+1}^{p}\Gamma(\varepsilon_j - e_j\xi - e_j\eta)\ \prod_{j=1}^{s}\Gamma(\delta_j + d_j\xi + \eta d_j)}$$

The function is not only a generalisation of *H*-function of one variable but also of *G*-function of two variables defined by Agarwal, R. P. Here the authors have discussed its behaviour for large and small values of x and y ; some of their properties and recurrence relations and integrals connected with it.

78. Polarographic study on the influence of substituents on the reduction of Aromatic Nitro compounds.

S. L. GUPTA AND NAWAL KISHORE, *Department of Chemistry, B. I. T. S., Pilani.*

Nitrobenzene was taken as the parent compound. The theory of irreversible reaction rates as developed by Koutecky was applied. The rate constants were determined at different potentials. These obeyed the Eyring Equation $k = k_0 e^{-nFE/RT}$. From the data, the values of rate constants at $E_{0\cdot25}$, $E_{0\cdot5}$ and $E_{0\cdot75}$ were determined. The influence of substituents on rate canstants was studied Hammett's Rule was applied to the values of rate constants at $E_{0\cdot25}$, $E_{0\cdot5}$ and $E_{0\cdot75}$ which gave satisfactory results.

79. On H-function transform—I.

A. B. MATHUR AND R. D. AGRAWAL, *Department of Mathematics, S. A. T. I. Vidisha*

In this paper, the authors have defined the following generalised transform

$$\phi(s) = \int_0^\infty H\,{}^{m\,n}_{p\,q}\left[sx \,\middle|\, \begin{matrix}(a_1, \alpha_1), (a_2, \alpha_2), \ldots, (a_p, \alpha_p)\\ (b_1, \beta_1), (b_2, \beta_2), \ldots, (b_q, \beta_q)\end{matrix}\right] f(x)\,dx,$$

where the kernel is the H-function of Fox.

This transform reduces to most of the known generalised Laplace, Hankel and Stieltijes transforms. An inversion formulae is also proved.

80. A note on new class of Polynomials $T_n^{\alpha,k}(x, r, p)$

R. C. SINGH CHANDAL, *Department of Mathematic, S. A. T. D. Vidisha (M. P.)*

In this paper the author has made the further study on the polynomials already introduced by using the operator $\delta_x = x^k D$ and defined by the Rodrigues' formula

$$T_n^{\alpha,k}(x, r, p) = x^{-\alpha} e^{px^r} (\delta x)^r \{ x^\alpha e^{-px^r} \}$$

in his earliar papers. Explicit formula and generating functions for $T_n^{\alpha,k}(x,r,p)$ has been obtained. In this paper it has also been pointed out that one can make a further study on generalized Stirling numbers. In the last the following theorem has also been established :

Theorem :

If $\sigma_n^{\alpha,k}(x, r, p)$ = the determinant of $\left[\left\{ T^{\alpha,k}_{n+i-j}(x, r, p) \right\} \right], 0 \leqslant i, j \leqslant m$

and

$$W\left(T_n^{\alpha,k}(x, r, p), \ldots\ldots, T^{\alpha,k}_{n-m}(x, r, p) \right)$$

$$= \text{the determinent of} \left[\left\{ \delta_x{}^i \; T^{\alpha,k}_{n-j}(x, r, p) \right\} \right], 0 \leqslant i, j \leqslant m$$

Then

$$\sigma_n^{\alpha,k}(x, r, p) = W \left\{ T^{\alpha,k}_{n}(x, r, p), T^{\alpha,k}_{n-1}(x, r, p), \ldots, T^{\alpha,k}_{n-m}(x, r, p) \right\}.$$

81. Some rules in Laplace Transform of one and two variables

VINOD PRAKASH SAXENA, *Department of Mathematics, S. A. Tech. Instt. Vidisha, M. P.*

In this paper some new rules, in the Laplace transform of one and two variables, have been established. Two typical examples are given below :

(*i*) If

$$f(p) \doteqdot h(x)$$

then,

$$f(a\log p+b\log(p^{\nu}+\alpha)+c\log(p^{\tau}+\beta)) \doteqdot \tau'^{1}\sum_{r=0}^{\infty}\frac{(-\alpha)^r}{r!}$$

$$\times\int_0^{\infty}\frac{x^{(a+b\nu+c\tau+b'r)t-1}}{\Gamma(bt)\,\Gamma(ct)\,\Gamma(b\nu t+\nu r)}\;H_{1,2}^{1,1}\left[\beta^{1/\tau}x\,\middle|\,\begin{matrix}(1-ct,\,1/\tau)\\(0,\,1/\tau),\,(1-\nu bt-btr-at-\tau ct,\,1)\end{matrix}\right]h(t)\,dt$$

provided $Re(p)>0$, $Re(a)>0$, $Re(b)\geqslant 0$, $Re(c)\geqslant 0$, $Re(\nu)\geqslant 0$, $Re(\tau)\geqslant 0$, $|Re(\alpha/p)|<1$, $|Re(\beta/p)|<1$.

(*ii*) If

$$f(p,q) \doteqdot\doteqdot h(x,y) \qquad \text{then,}$$

$$F(a\log p+b\log(p^{\nu}+\alpha)+c\log(p^{\tau}+\beta),\ a'\log q+b'\log(q^{\nu'}+\alpha')+c'\log(q^{\tau'}+\beta'))$$

$$\doteqdot\doteqdot(\tau\tau')^{-1}\sum_{r=0}^{\infty}\sum_{k=0}^{\infty}\frac{(-\alpha)^r}{r!}\frac{(-k')^k}{k!}\int_0^{\infty}\int_0^{\infty}\frac{x^{(a+b\nu+c\tau+b'r)u-1}\,y^{(a'+b'\nu'+c'\tau'+b'k')v-1}}{\Gamma(bu)\,\Gamma(cu)\,\Gamma(b'v)\,\Gamma(c'v)\,\Gamma(b\nu u+\nu r)}$$

$$\times\frac{\Gamma(bu+r)\,\Gamma(b'v+k)\,h(u,v)}{\Gamma(b'\nu'v+\nu'k)}\;H_{1,2}^{1,1}\left[\beta^{1/\tau}x\,\middle|\,\begin{matrix}(1-cu,\,1/\tau)\\(0,\,1/\tau),\,(1-b\nu u-bru-au-c\tau u,\,1)\end{matrix}\right]$$

$$\times H_{1,2}^{1,1}\left[\beta'^{1/\tau'}y\,\middle|\,\begin{matrix}(1-c'v,\,1/\tau')\\(0,\,1/\tau'),\,(1-b'\nu'v-b'kv-a'v-c'\tau'v,\,1)\end{matrix}\right]du\,dv,$$

provided $Re(p)>0$, $Re(q)>0$, $Re(a)\geqslant 0$, $Re(b)\geqslant 0$, $Re(c)\geqslant 0$, $Re\,(a')\geqslant 0$, $Re(b')\geqslant 0$, $Re(c')\geqslant 0$, $Re(\nu)\geqslant 0$, $Re(\nu')\geqslant 0$, $Re(\tau)\geqslant 0$, $Re(\tau')\geqslant 0$, $|Re(\alpha/p)|<1$, $|Re(\beta/p)|<1$, $|Re(\alpha'/q)|<1$, $|Re(\beta'/q)|<1$.

82. Some formulae for Jacobi polynomials.

R. K. SAXENA AND P. C. MUNOT, *Jodhpur University.*

In this paper the authors establish a finite summation formula for the Lauricella's hypergeometric function of n variables F_A and deiive some generating functions for the Jacobi polynomials by specializing the parameters in F_A . Most of the results appear to be new. Munot's formula given recently in Proc. Combridge Philos. Soc. (1969), follow as a very particular case of our result. The main formula proved is

$$\sum_{m+0}^{n}\frac{(-1)^{m+n}}{m!\,(n-m)!}F_A\ (\nu;-m,\,m-n,\,\lambda_1,\,\ldots,\,\lambda_s;\,1+\alpha,\,1+\beta,\,\mu_1,\,\ldots,\,\mu_s;\,x,\,y,\,a_1,\,\ldots,\,a_s)$$

$$=\frac{(\nu)_n\,(x+y)^n}{(1+\alpha)_n\,(1+\beta)_n}\,P_n^{(\alpha,\beta)}\left(\frac{y-x}{y+x}\right)\,F_A\ (\nu+n;\,\lambda_1,\,\ldots\lambda_s;\,\mu_1,\,\ldots\mu_s;\,a_1,\,\ldots,\,a_s)$$

83. Wanzlic oxidation with 3-Hydroxycoumarins.

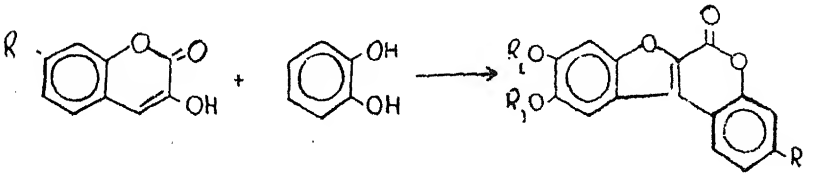
J. N. Chatterjea, K. Achari and N. C. Jain, *Chemistry Dept., Patna University.*

Wanzlic and co-workers have shown that catechol could be oxidatively coupled with suitable 1,3-dicarbonyl compounds in the presence of potassium-ferricyanide to give benzofuran derivatives. Thus dimedon, dihydroresorcinol and 4-hydroxycoumarins were used with success. A synthesis of wedelolactone was made possible from catechol and 4,5-dihydroxy-7-methoxycoumarin. Similarly other comestans have been prepared for the total synthesis of pterocarpin and erosnin.

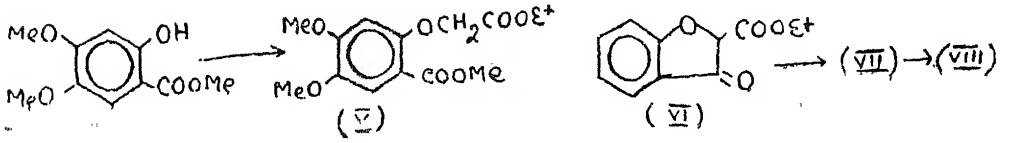
Mentzer *et al.* have used 6-methyl 1-4-hydroxy-α-pyrone to give 5,6-dihydroxy-2,3-(6'-methyl, 3', 4'-α-pyrono) benzofuran and 6-phenyl -4-hydroxy -α-pyrone to yield the analogous 6-phenyl derivative.

We find that Wanzlic oxidation proceeds smoothly with 3-hydroxycoumarins as well. Thus 3-hydroxycoumarin and catechol gave 5,6-dihydroxycoumarine (3',4'-2,3) coumarone (I) which was subsequently methylated to (II), m. p. 291-2° (IR, lactone carbonyl absorption at 1729·6 cm^{-1}), 7-Methoxy-3-hydroxycoumarin and catechol gave 5,6-dihydroxy-7'methoxycoumarino (3', 4'-2, 3) coumarone (III) in excellent yield. This was also converted to its trimethyl ether (IV), m.p. 268-70° (IR, lactone carbonyl band at 1710 cm^{-1}). The latter has now been synthesised unambiguously following the usual classical route.

Thus ethyl 2 hydroxy-4, 5 dimethoxybenzoate was condensed with ethyl-bromoacetate to give the diester (V), m.p. 87° which on Deickmann's cyclisation efforded ethyl-5, 6-dimethoxy-3'-coumarone-2-carboxylate (VI), m.p. 144-5° (IR, carbonyl stretching at 1675 cm^{-1} which on Pechmann's condensation with resorcinolmonomethylether gave 5, 6, 7'-trimethoxycoumarino (3',4'-2, 3) coumarone, m.p. 268-69°, identical in all respects with the wanzlic oxidation product (IV) (IR, lactone carbonyl absorption for both at 1720 cm^{-1}). The condensation of ethyl-5, 6-dimethoxy- β coumaronone-2-carboxylate was also done with resorcinol to give-5, 6-dimethoxy-7'-hydroxycoumarino (3', 4'-2, 3) coumarone (VII), m.p. 310 (IR, lactone carbonyl absorption at 1730 cm^{-1}). The latter was methylated to (IV), and acetylated to (VIII), m.p. 295° (IR, lactone carbonyl at 1725, acetoxy carbonyl at 1760 and -0-CO- bending frequency at 1240 cm^{-1})



(I) : R = R_1 = H
(II) : R = H, R_1 = CH_3
(III) : R = OMe, R_1 = H
(IV) : R = OMe, R_1 = CH_3
(VII) : R = OH, R_1 = CH_3
(VIII) : R = $OCOCH_3$, R_1 = CH_3



84. Thermal Stresses in a Semi-space due to a constant flux of heat over an infinite strip of the bounding plane.

S. C. Das and S. C. Prasad, *Department of Mathematics, Birla Institute of Technology, Mesra, Ranchi.*

This investigation is concerned with uncoupled thermal stress-distribution generated in an isotropic elastic sami-space due to a constant flux of heat supplied over an infinite strip- $-a < x < a, -\infty < y < \infty$ of the bounding plane $z = 0$. The body is supposed to be free from external loads and is initially to zero temperature.

85. Ultrasonic absorption in Vanadyl sulphate.

S. K. Kor and S. S. Bhatti, *Department of Physics, Allahabad University.*

Ultrasonic absorption measurements have been made in aqueous Vanadyl Sulphate at 25°C in the frequency range 30Mc/s to 100 Mc/s. A new relaxation frequency is observed which is strongly concentration dependent and is attributed to second step of the Eigen three step ion-association mechanism [Z. Electrochem 66, 93–107, (1962)]. The first step is diffusion-controlled and the relaxation corresponding to it is supposed to lie near 200Mc/s. The relaxation observed in the lower frequency range by Köhler and Wendt [Z. Physikalische chemie 70, 674–681 (1966)] is attributed to the third step. The equilbrium constant and the over-all association constant agree well with their values obtained from NMR and Conductance measurement method respectively, justifying amply the ion-association model chosen.

86. Reduction of Vanadium (*v*) with Vanadium (*ii*) and Vanadium (*iii*)

R. K. Prasad and K. K. Singh.

The successive oxidation states in the reduction of Vanadium (*v*) with Vanadium *ii*) under different concentrations of mineral acid have been realised through potentiometric titrations in both senses, *i.e.*, with the former in the cell and the latter in the burette and *vise-versa*. The scheme of reduction when Vanadium (*ii*) is added gradually to Vanadium (*v*) may be represented as Vanadium (*v*) → V(*iv*) → V(*iii*) whereas in the reverse case as V(V) → V(III) → V(*iv*). In view of the different geometries of the reacting ions and their products in solutions, direct electron transfer is not possible. A simple and convenient mechanism would be through a Hydrogen bridged inner sphere complex between the liganded . . H_2O molecules or OH groups followed by the transfer of a H atom.

Titrations have been performed with Pt, Au and Hg electrodes, and their comparative behaviour studied. Pt electrode behaves erratically under highly reducing solutions and fails to detect both the inflexions. The e. m. f. data have been utilised for calculating the standard formal potentials at several concentrations of mineral acid (. . . . . H_2SO_4). The upper limit of noble behaviour of mercury electrode in highly oxidising solutions has also been ascertained. Comparative behaviour of the platinum, gold and mercury electrodes in the potentiometric titrations of V(*v*) with V(II), V(*v*) with *v*(*iii*), and V(iV) with V(*ii*) solutions has been investigated. Reactions studied have great analytical significance.

87. The barrier to internal rotation in Dimethyl-amides.

VIJAY KUMAR, *Department of Physics, N. Engineering College, Hyderabad.*

The barrier to internal rotation in two N, N-dimethyl amides are calculated by the Huckel Molecular Orbital method using the concept of cis-trans localization energy. The bond orders of the C-N bonds are determined and related to the experimental barrier heights.

88. Reduction Vanadium (V) with Molybdenum (III).

R. K. PRASAD AND K. K. SINGH,

The reduction of Vanadium (V) with gradual addition of molybdenum (*iii*) follows the scheme

$$V(V) \rightarrow V(IV) \rightarrow V(III)$$
$$Mo(III) \rightarrow Mo(VI) \rightarrow Mo(V)$$

and in the reverse case the scheme

$$V(V) \rightarrow V(III) \rightarrow V(IV)$$
$$Mo(III) \rightarrow Mo(V) \rightarrow Mo(VI)$$

The fact that in neither case, more than two inflexions are noticed shows that the intermediate vanadium and molybdenum species are reduced and oxidised not consecutively but simultaneously. Gradual additions of V(V) to a mixture of V(II) and Mo(III) results in V(II) being oxidised first to V(III), then Mo(III) to Mo(V) and finally the simultaneous oxidation of V(III) and Mo(V) to V(IV) and Mo(VI) respectively. These results have been experimentally realised through potentiometric titrations using platinum and mercury electrodes.

The overall oxidation reductions are noncomplementary. But reactions proceed through individual one electron complementary steps. Thus the first step of the reduction of V(V) with Mo(III) proceeds according to the mechanism

$$V(V) + Mo(III) = V(IV) + Mo(IV)$$
$$V(V) + Mo(IV) = V(IV) + Mo(V)$$
$$V(V) + Mo(V) = V(IV) + Mo(VI)$$

The mechanisms of the electron transfer in each step is to be decided by the nature of liganding groups. In view of the hydrated nature of the reacting particles, H atom transfer mechanism is most probable.

89. Newton's cooling coefficients of some clay-liquid systems.

S. K. DE, R. K. SHUKLA AND SHYAM LAL, *Chemical Laboratories, Allahabad University.*

Newton's cooling coefficients (k) for 18 samples comprising 8 types of clay minerals, *viz.* montmorillonite, pyrophillite, muscovite, biotite, attapulgite, halloysite, vermiculite and kaolinite have been determined in aqueous and non-aqueous media. The k values have been found to be independent of the amount of clay mineral and to depend upon the nature of the clay mineral and the liquid used for preparing clay-liquid suspension ; the values can be used for the identification of clay minerals.

90. Transition probabilitie s for Electronic Spectra of Li_2 and C_2

A. N. SINGH, *Department of Physics, Magadh University, Gaya,* AND D. K. RAI, *Department of Spectroscopy, Banaras Hindu University, Varanasi.*

The methods described in detail by Mulliken and Rieke, using the LCAO MO and the AO wave functions, for calculations of the transition probabilities have been applied for $A^1\Sigma_u^+ - X^1\Sigma_g^+$ and $c^1\Sigma_u^+ - X^1\Sigma_g^+$ transitions for Li_2 and $b^1\pi_u - X^1\Sigma_g^+$, $B^3\pi_g - X^3\pi_u$ $d^1\Sigma_u^+ - X^1\Sigma_g^+$, $c^1\pi_g - b^1\pi_u$, and $A^3\pi_g - X^3\pi_u$ transitions for C_2. The results obtained are in good agreement, in the case of C_2 for $^3\pi_g - {}^3\pi_u$ and $^1\pi_g - {}^1\pi_u$ transitions, with the previous work of Shull.

91. Effect of varying Initial Stress on Love Wave.

S. C. DAS AND S. DEY, *Mathematics Deptt., Birla Institute of Technology, Ranchi.*

The velocity of propagation of Love Wave in the media with variation in rigidity and density has been studied by Meissner, Willson, Jeffreys, Sato, Dasgupta and Others (2). The velocity of propagation of Love Wave under uniform Initial Stress has been obtained in earlier paper (3). In this paper, the variation in the Initial Stress due to gravity has been discussed. Whittaker's function has been used to obtain the result.

92. Stresses in a Circular Disk with an Eccentric Hole due to equal and opposite point-couples acting at two symmetrical points on a diameter passing through the hole.

MAHESH NARAYAN LAL, *Physics Dept., Birla Institute of Technology Mesra, Ranchi.*

The problem investigated in this paper is that of stress distribution in a thin circular disk having an eccentric circular hole, when two equal and opposite point-couples are applied at two points situated symmetrically on a diameter passing through the hole, the inner and the outer edges of the disk being stress-free. The solution is in bipolar co-ordinates.

93. Electroluminisence in hydrogen coactivated zinc sulpho-selenide phosphors.

S. G. PRAKASH AND HARI MOHAN, *Physics Department, University of Allahabad.*

A series of copper-doped sulpho-selenide solid solutions, giving electroluminescent emission right from blue to the red, have been prepared using ZnS and ZnSe in varying proportions. Hydrogen acted as the effective donor impurity in all cases. It was found that with stepwise rise in the proportion of selenide component of the host matrix, the emission peaks shift successively towards higher wavelengths. However, on frequency variation while the samples with ZnS-ZnSe composition showed marked peak-shifts in their respective emissson bands, no such effect could be observed in samples with single base lattice composition.

LIST OF MEMBERS AND FELLOWS

(Completed upto 31st March, 1968)

[*Names of Fellows are marked with* * ; *and of Life Members with* †]

Achari, G., M.B.B.S. (Hons.), Ph.D., Professor and Head of the University Department of Pharmacology, P. W. Medical College, Patna.

Agarwal, A. K., M.Sc., Ph.D., Lecturer in Chemistry, M.M.M. Engineering College, Gorakhpur.

Agarwal, B. M., M.A., Lecturer in Mathematics, Govt. Science College, Gwalior.

Agarwal, G. P., M.Sc., D.Phil., Lecturer in Botany, Government Science College, Jabalpur.

Agarwal, Hira Lal, M.Sc., D.Phil., Reader in Maths., College of Mining and Metallurgy, Banaras Hindu University, Varanasi.

Agarwal, Jyoti Prasad, M.A., Ph.D., Prof. and Head of the Mathematics Dept., Agra College, Agra.

Agarwal, K. P., M.Sc., Lecturer, Government H. S. School, Sasha Distt. Raipur (M. P.).

Agrawal, R. D., M.Sc., Lecturer in Maths., S. A. Tech. Institute, Vidisha.

Agarwal, S. C., M.Sc., Research Scholar, Deptt. of Botany, University of Saugar, Sagar.

†Agarwal, Ved Prakash, M.Sc., Ph.D., Professor and Head of the Zoology Dept. D. A. V. College, Muzaffarnagar.

Agarwal, Vinod, (Miss), M.Sc., Research Scholar in Zoology, University of Lucknow, Lucknow.

Agarwala, S. C , M.Sc., Ph.D., F.A.Z., F.Z.S., Deptt. of Zoology, Meerut College, Meerut.

Agnihotri, Virendra Prasad, M.Sc., c/o Agnihotri Engineering Works, Rudrapur, Naini Tal.

Agrawal, R. K., M.Sc., Agri. (Bot.), D.Phil., Senior Plant Pathologist, Mashabra, Simla-7 (H.P.)

Ahmad, Hasib Syed, M.Sc., Head of the Zoology Department, S. P. Jain College, Sasaram.

Ahmad, Naseer, M.Sc., Ph.D., Lecturer in Chemistry, Aligarh Muslim University, Aligarh.

Ahmad, Z. U., M.Sc., Senior Research Assistant, Section of the Plant Pathologist to the Government, U. P., Kanpur.

†Ahuja, Bhopindra Singh, M.Sc., Botanist, Survey of Medical Plants, Government of India Project, P. O. Gurukula Kangri (Dt. Saharanpur).

Ambasht, J. P., M.Sc., F.R.A.S., Deptt. of Mathematics, S. P. Jain College, Sasaram (Bihar).

Ambasht, R. S., M.Sc., Lecturer in Botany, Banaras Hindu University, Varanasi-5.

Anandani, Parmanand, M.A., Lecturer in Maths., Holkar Science College, Indore.

Ansari, Majid Husain, M.Sc., D.Phil., 493 Daryabad, Allahabad.

†Arora, R. K., M.Sc. (Hons.) Ph.D., Botanist, Plant Introduction Division, Indian Agricultural Research Institute, New Delhi.

Arora, S. K., M.Sc., Ph.D., Asstt. Chemist Oil Seeds, Punjab Agricultural University, Hissar (Haryana).

†Awasthi, P. N., M.Sc., D.Phil., Assistant Professor of Chemistry, University of Saugar, Sagar.

Bagchi, A. K., B.A. (Hons.), 'Amarapati', Indian Statistical Institute, 204 Barrackpore Trunk Road, Calcutta-35.

†Bahadur, K., M.Sc., D.Phil., D.Sc., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

Bajpai, S. D., M.Sc., Asst. Prof. in Mathematics, Govt. Degree College, Piparia, M. P.

†Bajpai, S. K., M.Sc., D.Phil., Deptt. of Botany, Saugar University, Sagar (M. P.).

Ballabh, Ram, M.Sc., Ph.D., Professor and Head of the Department of Mathematics, University of Lucknow, Lucknow.

*Banerjee, D. P., M.A., D.Sc., F.S.S., Professor and Head of the Department of Mathematics, Faculty of Science, University of Libya, Tripoli (Libya).

*†Banerjee, K. D.Sc., F.N.I., F.I.A.S., Retd. Director, Indian Association for the Cultivation of Science, Jadavpur, Calcutta-32.

Banerjee, K., D.Sc., F.N.I., Emeritus Professor, Ind. Assn. Cult. Sci., P. O. Noapara, *via* Barasat, Dist. 24 Parganas.

†Banerji, N. K., M.Sc., D.Phil., D.Sc., 26/13, Patkapur, Kanpur.

*†Banerji, S. K., D.Sc., F.A.Sc., M.A.E.S.I., Hon.F.R.Met.Soc., 3 Ramani Chatterji Road, P. O. Rashbehari Avenue, Calcutta-29.

*†Banerji, S. K., M.Sc., D.Phil., Associate Professor of Chemistry, Birla Institute of Technology and Science, Pilani (Rajasthan).

*Banerji, S. N., M.Sc., D.Phil., Reader in Chemistry, University of Saugar, Sagar.

Bansal, Om Prakash, M.Sc., Ph.D., Associate Prof. of Chemistry, Agra College, Agra.

Baranwal, Ram Lakhan, M.Sc., Lecturer, College of Technology, Banaras Hindu University, Varanasi-5.

Baruah, Hitendra Kumar, M.Sc., Ph.D., Prof. and Head of the Botany Deptt., University of Gauhati, P. O. Gauhati, University (Jhalukbari), Assam.

Basu Chaudhary, K. C., M.Sc., Ph.D., c/o Dr. T. C. Basu Chaudhary, Prosadpur House, Nagar Kanti, Agra-2.

*†Basu, S., M.Sc., F.N.I., Retired Director General of Observatories, L-25 Hauz Khas Enclave, New Delhi-16.

†Baugh, S. C., M.Sc., Ph.D., Assistant Professor of Zoology, University of Lucknow, Lucknow.

*Behari, Ram, M.A., Ph.D., Sc.D., F.N.I., F.A.Sc., 80, Darya Ganj, Delhi-6,

Bhagwat, W. V., D.Sc., Professor of Chemistry, Vikram University, Ujjain.

†Bhanot, V. B., M.Sc., Ph.D., Reader in Physics, Punjab University, Chandigarh-3.

Bharadwaj, O. N., M.Sc., Lecturer in Zoology, Holkar Science College, Indore, (M. P.).

Bhardwaj, S. N., M.Sc., Ph.D., F.B.S., Asst. Plant Physiologist, Division of Botany, Indian Agricultural Research Institute, New Delhi-12.

*†Bhargava, H. R., M.Sc., F.B.S., Assistant Professor of Botany, University of Saugar, Sagar.

*Bhargava, K. S., M.Sc., D.Phil., Ph.D., Professor and Head of the Botany Department, University of Gorakhpur, Gorakhpur.

†Bhargava, S. N., M.Sc., D.Phil., Botany Department, 28, Thornhill Road, Allahabad.

Bharteya, Premlal, M.Sc., Lecturer in Mathematics, Department of Mathematics, St. Aloysius' College, Jabalpur (M. P.).

Bhatia, B. B., B.V.Sc.&A.H., M.V.Sc., Research Officer (Parasitology), U. P. College of Veterinary Science and Animal Husbandry, Mathura.

Bhatia, Prem Kumar, M.Sc., Ph.D., Lecturer in Mathematics, University of Jodhpur, Jodhpur.

Bhatnagar, A. N., M.Sc., D.Phil., Head of the Zoology Deptt. S.G.R.R., College, Dehra Dun.

*Bhatnagar, P. L., M.Sc., D.Phil, D.Sc., F.N.I., F.I.A.Sc., Head, Deptt. of Applied Mathematics, Indian Institute of Science, Bangalore-12

Bhatnagar, R. P., M.Sc., Ph.D., Asst. Professor of Chemistry, Government College, Shivpuri (M. P.).

Bhatt, B. D., M.Sc., c/o Sri R. D. Bhatt, Naya Bazar, Naini Tal.

*†Bhattacharya, A. K., D.Sc., F.R.I.C. Professor and Head of the Department of Chemistry, University of Saugar, Sagar.

*†Bhattacharya, Abani K., D.Sc , F.R.I.C., Professor and Head of the Post-Graduate Department of Chemistry, J. and K. University, Jammu (Kashmir).

Bhattacharya, Arun K., M.Sc., Ph.D., Asst. Professor of Chemistry, University of Saugar, Sagar.

*Bhattacharya, A. P., M.A., Ph.D., Research Officer, Basic Research Division, Irrigation Research Institute, Roorkee.

Bhattacharya, P. K., M.Sc., Ph.D., Lecturer in Chemistry, Vikram University, Ujjain.

*†Bhawalkar, D. R., M.Sc., Ph.D., Professor and Head of the Department of Physics, University of Saugar, Sagar.

Bhise, Vinayak Madhav, M.Sc., Lecturer in Mathematics, Govindram Seksaria Technological Institute, Opp. Nehru Park, Indore.

Bhonsle, B. R., M.Sc., Ph.D., Professor of Mathematics, Govt. Engineering College, Jabalpur.

Bhowmick, K. N., M.Sc., Ph.D., Lecturer in Mathematics, Department of Mathematics, Engineering College, Banaras Hindu University, Varanasi-5.

Bihary, Girdhar, M.Sc., Asst. Prof. of Mathematics, Ranchi College, Ranchi.

*Bilgrami, K. S., M.Sc., D.Phil., D.Sc., Reader in Botany, University of Jodhpur, Jodhpur.

*†Biswas, B., M.Sc., Maewal Compound, Nawabganj, Kanpur.

Bora, S. L., M.Sc., Senior Teacher in Mathematics, Govt. M. P. H. Secondary School, Sojat City (Rajasthan).

*†Bose, K. C., M.Sc., D.Phil., Professor and Head of the Department of Zoology, Ranchi University, P. Box. No. 11, Ranchi.

*Bose, Sameer, M.Sc., Ph.D., 310, Napier Town, near Christian High School, Jabalpur.

Braru, P. N., M.Sc., Research Scholar in Botanv, School of Studies in Botany, Vikram University, Ujjain (M. P.).

Capoor, V. N., M.Sc., Department of Zoology, Allahabad University.

Chakrabarty, R. D., M.Sc., Research Officer, Central Inland Fisheries Research Centre, 19 Cantonment Road, Cuttack-1.

*†Chakravarti, B., M.Sc., D.Phil., Agfa Photopaper Co., Mulund, Bombay-80.

*Chakravarti, S. C., M.Sc., Ph.D., Principal, Government Degree College Mhow (M. P.).

†Chakravarty, D. N., M.Sc., D.Phil., National Carbon Company, 5 Rustomji Parsee Road, Calcutta-2.

Chakraverti, B. P., Ph.D., Reader in Plant Pathology, Officer-in-Charge, Plant Pathology Research Division, Agricultural Experiment Station, Udaipur.

Chandel, Bijai Singh, M.Sc., Ph.D., Asst. Prof. of Zoology, B. R. College, Agra.

Chandel, R. C. Singh, M.Sc., Research Scholar, Dept. of Mathematics, S. A. Tech. Institute, Vidisha.

Chandra, Jagdish, M.A., Department of Mathematics, Mason Laboratories, Rensselaer Polytechnic Institute, Troy, N. Y. (U.S.A.).

Chandra, Sudhir, M.Sc., D.Phil., Department of Botany, University of Allahabad, Allahabad.

Chandra, Sudish, M.Sc., Research Scholar, Chemistry Department, University of Lucknow, Lucknow.

Chatterjea, J. N., D.Phil., D.Sc., F.R.I.C., F.I.C., Professor of Chemistry, Patna University, Patna-5.

*†Chatterjee, A. C., D.Sc., Dr. Ing., c/o Department of Chemistry, University of Lucknow, Lucknow. Residence : 216, New Hyderabad, ~~Allahabad~~. Lucknow

Chatterjee, Peetendu, M.Sc., Asst. Manager, Durrung Tea Estate –Modopee Division, P. O. Bindukuri, Dt. Darrang (Assam).

Chatterji, P. C., M.Sc., Geologist, Central Arid Zone Research Institute, Jodhpur.

†Chatterji, P. N., M.Sc., D.Phil., Department of Zoology, G. M. College, Sambalpur (Orissa).

*†Chatterji, R. G., M.Sc., D.Phil., Department of Physics, Indian Institute of Technology, Kharagpur.

*†Chatterji, U. N., D.Phil., D.Sc., F.R.S.A., Professor and Head of the Botany Department, University of Jodhpur, Jodhpur.

*†Chattoraj, A. N., M.Sc., D.Phil., F.E.S.I., F.R.E.S. (Lond), Reader in Zoology, Dept. of Zoology, University of Allahabad, Allahabad.

Chaturvedi, D. N., M.Sc., Research Scholar, Dept. of Chemistry, Agra College, Agra.

*†Chauhan, B. S., Ph.D., D.Sc., C.H.Z.S., F.A.Sc., F.Z.S.I., Superintending Zoologist, Zoological Survey of India, 34, Chittaranjan Avenue, Calcutta-12.

Chauhan, R. N. Singh, M.Sc., D.Phil., Asst. Professor of Chemistry, Th. D. S. B. Government College, Naini Tal.

Chauhan, Suresh Kumar, M.Sc., Ph.D., School of Studies in Botany, Vikram University, Ujjain.

Chhabra, S. P., M.Sc., Lecturer in Mathematics, Government Engineering College, Koni, Bilaspur.

*Chinoy, J. J., M.Sc., Ph.D., D.I.C., Head of the Department of Botany, Gujarat University, Ahmedabad.

†Chitray, Brij Behari, M.Sc., Head of the Biology Dept., H. S. J. S. College, Kanpur.

*†Chopra, Col. Sir R. N., C.I.E., M.D., Sc.D., F.R.C.P., Director, Regional Research Laboratory, Jammu and Kashmir, Canal Road, Jammu Tawi, Kashmir.

Chopra, H. N., Principal, Government College, Chamba.

Chopra, R. S., M.Sc., Reader in Botany, Punjab University, Amritsar.

Choudhari, R. S., M.Sc., Ph.D., D.Sc., Irwin Prof. of Agriculture and Principal, College of Agriculture, Banaras Hindu University, Varanasi-5.

Choudhary, R. C., M.Sc., Ph.D., Reader in Mathematics, Ranchi University, Ranchi.

Choudhry, R. K., Ph.D., Reader in Mathematics, L. S. College, Muzaffarpur.

Choudhuri, D. K., M.Sc., Ph.D., D.I.C., Head, Dept. of Zoology, University of Burdwan, P. O. and Dt. Burdwan (W. B.)

*†Chowdhary, H. S., M.Sc., D.Phil., Professor and Head of the Department of Zoology, University of Gorakhpur, Gorakhpur.

*†Chowdhury, K. A., B.A., B.Sc., M.S., D.Sc., F.N.I., Professor and Head of the Botany Department, Muslim University, Aligarh.

Chowdhury, S. R., M.Sc., Lecturer in Botany, Government College of Science, Raipur (M. P.).

Dalela, G. G., M.Sc., Ph.D., Junior Specialist, Plant Pathology Section, Department of Agriculture, Rajasthan, Udaipur.

Damle, V. P., M.Sc., Ph.D., Principal, Jankidevi Bajaj College of Science, Wardha.

†Das, Niranjan, M.Sc., D.Phil., Assistant Professor of Botany, University of Allahabad, Allahabad.

*†Das, S. M., D.Sc., F.Z.S., F.A.Z., F.Z.S.I., Professor of Zoology, Jammu and Kashmir University, Srinagar, Kashmir.

*†Das Gupta, S. N., Ph.D., D.Sc., D.I.C., F.N.I., Vice-Chanceller, University of Kalyani, 1-B Judge's Court Road, Calcutta-27.

Das Varma, R., M.Sc., Reader in Mathematics, University of Bihar, Muzaffarpur.

*†Dave, J. S., M.Sc., Ph.D., A.R.I.C., Professor of Chemistry, Faculty of Technology and Engineering, M. S. University, Baroda.

†David, A., B.Sc., D.Sc., Senior Research Officer and Officer Incharge, Central Inland Fisheries Research Institute, III Floor, Multistoryed Bdgs, K. R. Circle, Bangalore-I.

†Davis, T. A., B.A., P.G. Dip. (Crop Bot.), Professor of Crop Science, Indian Statistical Institute, Calcutta-35.

*Dayal, Bisheshwar, D.Sc., F.Inst.P., A.I.I.Sc., Reader in Physics, Banaras Hindu University, Varanasi-5.

Dayal, Ram, M.Sc., D.Phil., Department Pathology, College of Agriculture, Banaras Hindu University, Varanasi-5.

†Dehadrai, P. V., M.Sc., F.G.S., F.G.M.S., M.M.G.I., Senior Petrologist, Oil and Natural Gas Commission, Government of India, 19 Rajpur Road, Dehra Dun.

†De, Samarenda Kumar, B.Sc.,Ag., M.Sc., (Ag.Bot.), M.Sc., (Ag.Chem.), D.Phil., D.Sc., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

*†Deodhar, D. B., M.Sc., Ph.D., Anand Niwas, Havelock Road, Lucknow.

†Deshpande, P. K., M.Sc., Ph D., F.B.S., Reader in Botany, Dept., of Botany, (Near University Hostel) Nagpur University, Nagpur.

*†Dey, A. K., B.Sc., (Hons.), M.Sc., D.Phil., D.Sc., Reader in Chemistry, University of Allahabad, Allahabad.

*†Dey, P. K., M.Sc., I.Ag.S. (Retd.), 53/1 Southern Avenue, Calcutta-29.

Dhakre, J. S., M.Sc., Asst. Prof. of Botany, Balwant Rajput College, Agra-2.

†Dhar, A. K., M.Sc., Assistant Agricultural Officer, Ramnugger Cane and Sugar Co. Ltd., Plassey, District Nadia (W. B.)

*Dhar, M. L., M.Sc., Ph.D., F.R.I.C., F.N.I., Director, Central Drug Research Institute, Chattar Manzil Palace, Lucknow.

*†Dhar, N. R., D.Sc., F.R.I.C., F.N.I., I.E.S., (Retd.), *Associate Member of the French Academy of Agriculture* and *Corresponding Member of the French Academy of Sciences*, Director, Sheila Dhar Institute of Soil Science, University of Allahabad, 2 D-Beli Road, Allahabad-2.

*†Dhawan, C. L., M.Sc., Ph.D., Deputy Director, Land Reclamation, Irrigation and Power Research Institute, Amritsar.

Dhawan, G. K., M.A., Lecturer, Dept. of Mathematics, Maulana Azad College of Technology, Bhopal (M. P.).

*†Doosaj, S. S., M.Sc., Principal, Jail Road, Rewa (M. P.)

†Dugar, S. M., M.Sc., Research Scholar, Department of Chemistry, University of Rajasthan, Jaipur.

*†Dutta, S. K., D.Sc., 57 Tarakutir Road, Lukerganj, Allahabad.

Dwivedi, Ambik Prasad, M.Sc., Deptt. of Mathematics, I. I. T. Kanpur.

Dwivedi, M. P., M.Sc., Asst. Professor of Zoology, Government Degree College, Chhindwara (M. P.).

Dwivedi, R. S., M.Sc., Ph.D., Lecturer in Botany, Banaras Hindu University, Varanasi-5.

Gandhi, J. N., M.Sc., Reader and Head of the Physics Department, Maharani's College, Jaipur.

Gangoli, S. G., M.Sc., (M.S.S.A.), Lecturer in Physics Dept., Aligarh Muslim University, Aligarh (U. P.).

†Garg, N. K., M.Sc., D.Phil., Ph.D., Division of Biochemistry, Central Drug Research Institute, Lucknow.

Garg, Ved Prakash, M.Sc., Civilian Instructor Signals (C.G.O.), 3 Tech. Trg. Regt. (2 STC.), Bambolim (Goa).

Gaur, A. C., M.Sc., D.Phil., D.Sc., Soil Microbiologist, Division of Microbiology, Indian Agricultural Research Institute, New-Delhi-12.

*†Gayre of Gayre and Nigg, Lt. Col. Robert, K.C.N., K.C.M.M., K.C.L., G.C.L.J., M.A., D.Phil,, D.Pol.Sc., D.Sc., F.I.A.L., 1 Darnaway Street, Edinburgh-3 (Scotland).

†Ghadially, P. F., F.R.G.S., F.R.S.A., F.B.H.I., B.Sc., M.M.E.A., A.M.I.E., M.I.S.D., Messrs. Precists (India) Private Ltd., 43 Queen's Road, Bombay-2.

Ghoshal, Satish Chandra, B.A., B.Sc., LL.B., Retired Director of Education, Indore and Alwar States, 8, Vikramaditya Marg, Lucknow.

Ghosh, A. K., M.Sc., Central Research Lab., Antibiotic Project, P.O. Virbhadra, Rishikesh.

*†Ghosh, S., D.Sc., F.N.I, Professor and Head of the Department of Chemistry, University of Jabalpur.

*†Ghosh, S. C., M.Sc., D.Phil., Assistant Professor of Zoology, University of Allahabad, Allahabad.

*†Ghosh, S. K., M.Sc., D.Phil., Chief Soil Chemist, Fertilizer Corporation of India, Durgapur Division, Durgapur-1 (W.B.).

*†Ghosh, S. N., D.Sc., F.N.I., Professor of Applied Physics, J. K. Institute of Applied Physics, University of Allahabad, Allahabad.

*†Gill, P. S., M.Sc., Ph.D., M.A.P.S., F.N.I., Director, Central Scientific Instruments Organisation, Chandigarh.

Gokhroo, D. C., M.Sc., Lecturer, Dept. of Maths., Govt. College, Bhilwara (Raj.).

Golas, Prakash Chandra, M.Sc., Lecturer in Maths., Dept. of Mathematics, Govt. College, Kotputti (Raj.).

Goyal, A. N., M.Sc., Ph.D., F.R.A.S., Lecturer in Mathematics, Maharaja's College, Jaipur.

Goyal, G. K., M.Sc., Lecturer in Mathematics, University of Rajasthan, Jaipur.

†Grover, (Miss) Prabha, M.Sc., D.Phil., 14 Park Road, Allahabad 2.

Gujarati, (Miss) Savitri, Dr., M.Sc., Ph.D., Senior Research Fellow, Botany Department, Banaras Hindu University, Varanasi-5.

Gulati, S. P., M.A., D.I.I.T., Department of Mathematics, Indian Institute of Technology, Kanpur.

†Gupta, A. B., M.Sc., Ph.D., Head of the Botany Department, Christ Church College, Kanpur.

*†Gupta, A. C., B.Sc., F.H.B.T.I., F.R.I.C., Professor of Oil and Allied Technology, Harcourt Butler Technological Institute, Kanpur.

Gupta, D. P., M.Sc., Research Scholar in Zoology, University of Saugar, Sagar.

*Gupta, D. R., M.Sc., Ph.D., Professor, Dept. of Chemistry, School of Basic Science and Humanities, U. P. Agrcultural University, Pantnagar, Naini Tal.

Gupta, K. C., M.Sc., Ph.D., Reader in Mathematics M. R. Engineering College, Jaipur.

†Gupta, Munendra Nath, M.Sc., Ph.D., I.B.S., Associate Professor of Botany, Agra College, Agra.

†Gupta, Puran Chandra, M.Sc., D.Phil, Lecturer, Department of Chemistry, University of Allahabad, Allahabad.

Gupta, R., M.Sc., Department of Zoology, Kanya Kubja College, Lucknow.

Gupta, R. B., M.Sc., Lecturer in Zoology, M. S. College, Motihari (Champaran) Bihar.

Gupta, R. K., M.Sc., Ph.D., Dr.-es Sciences, Section of Systematic Botany and Ecology, Central Arid Zone Research Institute, Jodhpur.

Gupta, R. P., M.Sc., Ph.D., Professor of Mathematics, D. S. B. Government College, Naini Tal.

†Gupta, R. S., M.Sc., Officiating Reader in Mathematics, University of Allahabad, Allahabad.

Gupta, S. C, M.Sc., Lecturer in Mathematics, Govt. College, Kota, (Rajasthan).

†Gupta, S. C., M.Sc., Ph.D., D.I.C., F.B.S., Professor and Head of the Botany Dept., K. N. Govt. Degree College, Gyanpur. (Dt. Varanasi).

Gupta, S. L., B.Sc. (Hons.), M.Sc., Ph.D., Shivaji College, University of Delhi, Delhi.

Gupta, Y. K., M.Sc., D.Phil., Reader in Chemistry, University of Rajasthan, Jaipur.

Gurtu, Shiv Kumar, M.Sc., Research Scholar, Deptt. of Mathematics, Allahabad University.

Gurtu, Vishnu Kumar, M.Sc., D.Phil., Reader, Dept. of Mathematics, University of Nagpur, Nagpur.

*†Gyani, B. P., M.Sc., Ph.D., Principal, Ranchi College, Ranchi.

Gyanvati, D.Phil, Junior Scientific Officer, Defence Research Laboratory (Stores), Kanpur.

*Handa, K. L. M.Sc., F.R.I.C., F.I.C., Senior Scientific Officer, Regional Research Laboratory, Jammu (Kashmir).

Hariharan. T. A., M.Sc., Ph.D., Lecturer in Physiscs, Karnataka Regional Engineering College, Surathkal P. O. (S. K.), Mysore State.

Harit, Sudhanshu, M.Sc., Lecturer in Mathematics, G. R. C. College, Fatehpur (Raj.).

Haidar, Mohd. Haseen Uddin, M.Sc., Research Scholar, Deptt. of Zoology, University of Gorakhpur, Gorakhpur.

†Hasija, S. K., M.Sc., Ph.D., Lecturer in Botany, Govt. Science College, Jabalpur.

Hussain, Izhar, M.Sc., Ph.D., D.Sc., Professor and Head of the Deptt. of Maths., Regional Engineering College, Srinagar.

Indrasena, A., M.Sc., Research Scholar in Mathematics, Osmania University, Hyderabad. (A. P.).

Jain, K. D., M.Sc., Ph.D., A.R.I.C., Professor and Head of the Chemistry Department, D. A. V. College, Dehra Dun.

Jain, M. K., M.Sc., Principal, Sahu Jain College, Najibabad (U. P.).

Jain, R. N., B.A. (Hons.). M.A., Asst. Professor of Mathematics, Holkar Science College, Indore.

*†Jain, S. K., M.Sc., Ph.D., F.B.S., Botanical Survey of India, P. O. Indian Botanical Gardens, Calcutta.

†Jain, S. L., M.Sc., Ph.D., Geological Studies Unit, Indian Statistical Research Institute, 203, Barrackpore Trunk Road, Calcutta-35.

Jain, U. C., M.Sc., Lecturer in Mathematics, M. B. College, University of Udaipur, (Rajasthan).

Jaiswal, M. P., M.Sc., Research Scholar, Deptt. of Mathematics, B. H. U., Varanasi-5.

Jaiswal, S. P., M.Sc., D.Phil., Asstt. Sugarcane Chemist, Sugarcane Research Station, Jullunder Cantt. (Panjab).

Jaitley, (Miss), Priyamvada, M.Sc., D.Phil., Lecturer in Zoology, Govt. Hamidia College, Bhopal.

Jha, D. K., M.A., B.L., Ph.D., Lecturer in Mathematics, L. S. College, Muzaffarpur.

Jha, S. N., B.Sc., (Hons.), M.Sc., Lecturer in Mathematics, L. S. College, Muzaffarpur.

*Jhingran, A. G., M.Sc., Ph.D., F.N.I., F.G.M.S., M.M.G.I., Director, Eastern Region, Geological Survey of India, 5, Middleton Street, Calcutta-15.

Jhingran, V. G., M.Sc., Ph.D., Director, Central Inland Fisheries Institute, Barrackpur (W. B.).

Johri, L. N., D.Sc., Reader in Zoology, University of Delhi, Delhi-7.

*Joshi, A. C., D.Sc., F.N.I., Vice-Chancellor Punjab University, Chandigarh–3.

Joshi, Chandra Mohan, M.Sc., Lecturer in Math., Department of Maths., University of Jodhpur, Jodhpur.

Joshi, Damodar Gopal, M.Sc., Lecturer in Mathematics, 49, Vasudeonagar Manikbagh Road, Indore.

Joshi, N. C., M.Sc., Ph.D., F.B.S., Asst. Systematic Mycologist, Directorate of Plant Protection, 4/19 Ajmeri Gate Extension, New Delhi.

Kabir-Ud-Din, M.Sc., Junior Research Fellow, Deptt. of Chemistry, Aligarh Muslim Universtiy, Aligarh.

Kacker, G. N., M.B.B.S., M.S., M.Sc., Anatomy (London), Professor and Head of Anatomy Department, S. N. Medical College, Agra.

Kahate, Sindhu, M.Sc., Lecturer in Botany, Kamla Nehru Hall for Women, Universtiy of Jodhpur, Jodhpur.

Kalla, Shyam Lal, M.Sc., Research Scholar, Department of Mathematics, Malaviya Regional Engineering College, Jaipur.

Kamal, M. Usuf, M.Sc., Research Asst., Central Inland Fisheries Research Sub-Station, 30 Panna Lal Road, Allahabad.

Kamala, (Miss), P. S., M.Sc., Deptt. of Mathematics, University of Rhode Island, Kingston, Rhode Island, U.S.A.

Kant, Krishna, M.Sc., D.Phil., Reader in Chemistry, University of Jodhpur, Jodhpur.

*†Kapoor, R. C., M.Sc., D.Phil., D.Sc., Professor and Head of the Department of Chemistry, University of Jodhpur, Jodhpur.

*Kapur, J. N., M.A., Ph.D., F.A.Sc., Professor and Head of the Mathematics Department, Indian Institute of Technology, Kanpur.

*Kar, B. K., Ph.D., F.B.S., Head of the Botany Department, Viswa-Bharati, Santiniketan (W. B.).

Kathal, Prahlad Dass, M.Sc., Asst. Professor of Mathematics, Dept. of Mathematics, Govt. College, Ratlam (M. P.).

Kaul, M., Hans Raj College, University of Delhi, Delhi–6.

Kaul, V., M.Sc., Ph.D., Head of the Post-graduate Department of Botany, J. and K. Universtiy, Amar Singh Bagh, Srinagar, Kashmir.

Kaushic, S. D., M.A.. Ph.D., Professor and Head of the Geography Department, S. S. V. College, Hapur.

†Khan, Reayat, M.Sc., Ph.D., Department of Botany, Aligarh Muslim University, Aligarh.

†Khandekar, P. R., M.A., Professor of Mathematics, Government College, Bhind.

Khanna, S. S., M.Sc., Ph.D., Prof. of Zoology, D. S. B. Govt. College, Nainital.

Khanna, Prem Krishna, M.Sc., D.Phil., Lecturer in Science (A) Botany Regional College of Education, Shyamda Hills, Bhopal (M. P.).

Khare, H. C., M.Sc., Ph.D., Reader, Mathematics Deptt. University of Allahabad, Allahabad.

Khare, R. C., M.A., D.Phil., Lecturer in Mathematics, University of Allahabad, Allahabad.

Khichi, Kishan Singh, M.Sc., Research Fellow, Dept. of Mathematics, University of Jodhpur, Jodhpur.

Konar, S. K., M.Sc., Lecturer in Zoology, L. S. College, Muzaffarpur.

†Kothari, Hemraj, B.Sc., D.W.P., A.C.C.G.I., A.M.S.E., F.C.I., F.B.I.S., I.M.I., Conslt. E., A.M.A.I.M., Management and Technical Consultant and Chief Executive, Kothari Consultants, 12, India Exchange Place, Calcutta-1.

Koul, Awtar Kishen, M.Sc., Ph.D., Lecturer, Post-graduate Botany Department, Jammu and Kashmir University, Srinagar (Kashmir).

Koul, M. L. Hakoo, M.Sc., Research Officer, Range Office, Forest Research Institute, Dehra Dun.

*†Krishna, Bal, M.Sc., D.Phil., Reader in Chemsitry, Universtiy of Allahabad, Allahabad.

Krishna, Daya, M.Sc., D.Phil., Professor and Head of the Department of Zoology, Govt. College, Ajmer.

*Krishnaji, M.Sc., Professor and Head, Physics Department, University of Allahabad, Allahabad.

Krishnamurthy, K. N., B.Sc., (Hons.), Research Assistant, Central Inland Fisheries Research Institute, P. O. Tungabhadra Dam, Dt. Bellary, Mysore State.

Kshetrapal, (Miss), S., M.Sc., Research Scholar, Department of Botany, University of Saugar, Sagar.

Kulshreshtha, S. K., M.Sc., Dept. of Mathematics, S. A. Technical Institute, Vidisha (M. P.).

Kumar, Nishith, M.Sc., Research Scholar, Deptt. of Zoology, University of Gorakhpur, Gorakhpur.

*†Kumar, Ram, M.Sc., Ph.D., D.Sc., Professor of Mathematics and Head of the Department of Applied Mathematics, Applied Science and Humanities, M. L. N. Regional Engineering College, Allahabad.

*†Kushwaha, R. S., M.Sc., D.Phil., Ph.D., Professor and Head of the Department of Mathematics, University of Jodhpur, Jodhpur.

*Lahiri, A. N., M.Sc., Ph.D., Plant Physiologist,. Central Arid Zone Research Institute, Jodhpur (Rajasthan).

Lajpatrai, M.A., Lecturer in Mathematics, Osmania University, Hyderabad.

*†Lakhanpal R. N., M.Sc., Ph.D., F.B.S., Assistant Director, Birbal Sahni Institute of Palaeobotany, University Road, Lucknow.

†Lakshmikanth, V., M.A., Professor of Mathematics, University of Rhode Island, Kingston, Rhode Island, U. S. A.

†Lakshminarayana, G., M.A., Ph.D., Asst. Professor of Mathematics, Regional Engineering College, Warangal (A. P.).

Lakshminarayana, K. V., M.Sc., Asst. Zoologist, Zoological Survey of India, 34, Chittaranjan Avenue, Calcutta-12.

Lal, Bal Krishna, M.Sc., Lecturer in Mathematics, L. S., College, Muzaffarpur.

*Lal, J. B., D.Sc., B.S.E., (Chem. Engg.), M.S.E., F.I.C., M.I.Chem. E., Head of the Chemical Engineering Department, University of Roorkee, Roorkee.

†Lal, Krishna, M.Sc., D.Phil., Lecturer in Engineering Mathematics, Engineering College, Banaras Hindu University, Varanasi-5.

Lal, K. B., M.A., Ph.D., Assistant Professor of Mathematics, University of Gorakhpur, Gorakhpur.

Lal, M. B., M.Sc., Ph.D., M.A., LL.B., Head of the Zoology Dept., D. A. V. College, Dehra Dun.

Lal, R. N., Ph.D., Lecturer in Mathematics, Bhagalpur University, Bhagalpur.

Lall, S. B., M.Sc., Ph.D., Lecturer in Botany, College of Agriculture, Nagpur.

Lodha, M. S., M.Sc., Lecturer in Mathematics, Govt. College, Rewa, (M. P.).

Loiwal, S. D., M.Sc., D.Phil., Principal, Sanatan Dharm College, Muzaffarnagar.

*†Mahabale, T. S., B.A., M.Sc., Ph.D., F.N.I., F.A.Sc., F.B.S., Head of the Department of Botany, University of Poona, Ganeshkhind, Poona-7.

Mahajan, Ratan Lal, M.A., Lecturer in Mathematics, Madhav College, Ujjain.

†Mahajani, A. V., M.Sc., Ph.D., Reader in Chemistry, University of Saugar, Sagar.

*Mahalanobis, P. C., M.A., I.E.S., (Retd.)., F.R.S., F.N.I., Director, Indian Statistical Research Institute, 204, Barrackpore Trunk Road, Calcutta-35.

Maheshwari, Suresh Chandra, M.Sc., Lecturer, Deptt. of Zoology, J. B. College of Science, Wardha (M. P.).

*†Majumdar, K., D.Sc., 20 Minto Road, Allahabad-2.

Majupuria, T. C., M.Sc., Ph.D., Head of the Zoology Department, M. S. (Post-graduate) College, Saharanpur.

*Malik, W. U., M.Sc., Ph.D., D.Sc., Professor and Head of the Chemistry Department, University of Roorkee, Roorkee.

Mall, L. P., M.Sc., Ph.D., Head, School of Studies in Botany, Vikram University, Ujjain.

Maloo, Harbilas, M.Sc., Research Scholar in Mathematics, M. R. Engineering College, Jaipur.

Mandahar, C. L., M.Sc., (Hons.), Ph.D., Lecturer in Botany, Kurukshetra University, Kurukshetra (Panjab).

Mandal, D. K., M.Sc., Zoological Assistant, Insect Section, Zoological Survey of India, 34, Chittaranjan Avenue, Calcutta-12.

Mandal, Subodh Chandra, M.Sc., F.R.I.C., Additional Director of Agricultural Research, New Secretariat, Patna.

Manilal, K. S., M.Sc., Ph.D , Lecturer in Botany, Department of Botany, University of Kerala, Devagiri, Calicut-8.

*†Mani, M. S., D.Sc., Deputy Director, Zoological Survey of India, 34, Chittaranjan Avenue, Calcutta-12.

Mann, R. S., M.Sc., M.Ch.E., Ph.D., F.R.I.C., Associate Professor, Department of Chemical Engineering, University of Ottawa, Ottawa (Canada).

*†Manna, G. K., M Sc., D.Phil., P.R.S., D.Sc., Reader and Head of the Zoology Deptt., Kalyani University, Kalyani, Distt. Nadia (West Bengal).

Mansingh, Abhai, M.Sc., D.Phil., Senior Research Fellow, Physics Department, Agra University, Agra.

Mathur, B. L., M.Sc., Ph.D., Asst. Plant Pathologist, Plant Pathology Section, A-30 Tilak Nagar, Jaipur.

Mathur, B. P., M.Sc., c/o Dr. Tara Shanker Mathur, Brij Kutir, Arvind Marg, Jaipur.

*†Mathur, K. N., D.Sc., F.Inst.P., Scientist Emeritus, National Physical Laboratory, Hillside Road, New Delhi-12.

Mathur, L. M. L., M.Sc., Ph.D., F.A.Z., F.E.S.I., Asst. Entomologist, Agricultural Experiment Station, University of Udaipur, Udaipur.

†Mathur, P. B., M.Sc., D.Phil., Assistant Director, Central Electrochemical Research Institute, Karaikudi-3 (S. India).

*†Mattoo, B. N., M.Sc., Ph.D., D.Sc., Asst. Director, Forensic Science Laboratory, Govt. of Maharashtra, Byculla, Bombay-8.

*†Mehra, H. R., M.Sc., Ph.D., F.N.I., 33, Chatham Lines, Allahabad-2.

*Mehra, P. N., D.Sc., F.N.I., F.B.S., Professor and Head of the Department of Botany, Punjab University, Chandigarh-4.

†Mehra, Ram Krishna, M.Sc., Assistant Professor of Zoology, University of Allahabad, Allahabad.

*†Mehrotra, A. P., M.Sc., D.Phil., F.B.S., P.E.S.(1), Professor and Head of the Department of Botany, D. S. B. Government Degree College, Naini Tal.

*†Mehrotra, B. S., M.Sc., D.Phil., Assistant Professor of Botany, University of Allahabad, Allahabad.

Mehrotra, P. N., M.Sc., 60, Circular Road, Ranchi (Bihar).

*†Mehrotra, R. C., M.Sc., D.Phil., Ph.D., D.Sc., F.R.I.C., F.N.I., Professor and Head of the Department of Chemistry, University of Rajasthan, Jaipur.

Mehrotra, R. S., M.Sc., Ph.D., Asst. Professor of Botany, University of Saugar, Sagar.

Mehta, D. K., M.Sc., Research Scholar, Deptt. of Applied Mathematics, Govt Engineering College, Jabalpur.

Mishra, Deen Dayal, M.Sc., Pool Officer, Dept., of Post-graduate Studies and Research in Chemistry, University of Jabalpur, Jabalpur.

Mishra, Raja Ram, M.Sc., Ph.D., Lecturer in Botany, Department of Botany, Gorakhpur University, Gorakhpur.

*†Mishra, R. D., M.A., Ph.D., Chairman, Public Service Commission, U.P., 2-A, Park Road, Allahabad.

*†Mishra, R. S., M.Sc., Ph.D., D.Sc., F.N.I., Professor and Head of the Department of Mathematics, University of Allahabad, Allahabad.

*Misra, M. L., D.Sc., Professor and Head of the Department of Mathematics, University of Saugar, Sagar.

*Misra, A. P., M.Sc., Ph.D., Prof. of Mycology and Plant Pathology, Bihar Agricultural College, P. O. Sabour (Bhagalpur).

Misra, Narendra Mohan, M.Sc., (Ag.), Ph.D., Lecturer in Agronomy, College of Agriculture, Banaras Hindu University, Varanasi-5.

Misra, P. C., M.Sc., Ph.D., Lecturer in Botany, Dept. of Botany, University of Gorakhpur, Gorakhpur.

*Misra, R., M.Sc., Ph.D., F.B.S., F.N.I., Professor and Head of the Department of Botany, Banaras Hindu University, Varanasi-5.

*†Misra, R. C., M.Sc., Ph.D., F.G.M.S., M.M.G.I., F.P.S., Professor and Head of the Department of Geology, University of Lucknow, Lucknow.

†Misra, S. G., M.Sc., D.Phil., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

*†Mitra, A. K., M.Sc., Ph.D., Reader in Botany, University of Allahabad, Allahabad.

Mourya, D. P., M.Sc., Research Scholar, Holkar Science College, Indore.

†Mukerji, G. P., M.Sc., Head of the Department of Zoology, J. H. Government College, Betul (M. P.).

Mukherjee, S. R., M.Sc., D.Phil., Reader in Engineering Mathematics, Engineering College, Banaras Hindu University, Varanasi-5.

*†Mukherji, M. K., M.Sc., Ph.D., "Arun Prabha", Kalianiwas, P. O. Barrackpore, 24 Pargana (W. B.).

†Mukherji, P. K., M.Sc., Ph.D., F.B.S., No. 3, Tuka Ram Chawl, Sadar Bazar, Nagpur.

Mulick, U. P., B.Sc., Consulting Engineer and Principal, Hope Johnstone & Son, Consulting Architects, 9, Hasting Street, Calcutta.

Murad, Humayun, M.Sc., F.R.E.S. (London), Lecturer in Zoology, Dept. of Zoology, Aligarh Muslim University, Aligarh.

Murthy, S. N., M.Sc., Lecturer in Mathematics, G. S. Technological Institute, Indore.

Murti, Sri Krishna, M.Sc., Scientific Assistant, Central Circle, Botanical Survey of India, 10, Chatham Lines, Allahabad.

*†Mushran, S. P., M.Sc., D.Phil., Reader in Chemistry, Universisy of Allahabad, Allahabad.

Nagar, S. K., M.Sc., 18, Telegraph Traffic Place, Baird Road, New Delhi.

Naik, Y. G., M.Sc., Ph.D., Principal Professor of Physics and Dean of the Faculty of Science, Gujarat College, Ahmedabad.

Nair, G. U., M.Sc., Research Assistant, Botany Department, Christ Church College, Kanpur.

Narain, Gopal, M.Sc., Ph.D., Lecturer in Chemistry, University of Lucknow, Lucknow.

†Narain, Udai, M.Sc., Ph.D., Head of the Botany Department, Rajendra College, Chapra.

*Narlikar, V. V., M.A., F.R.A.S., F.N.I., F.A.Sc., (Emeritus Prof. of Maths., Banaras Hindu University) Lokmanya Tilak, Prof. of Applied Maths. University of Poona, Poona-7.

*†Nath, Raj, Ph.D., D.I.C., F.N.I., Professor and Head of the Department of Geology, Banaras Hindu University, Varanasi-5.

Nath, Surendra, M.Sc., Head of the Zoology Dept., Govt. Degree College, Poonch, (J. & K. State).

Neema, Laxmi Narain, M.Sc., Asst. Prof. of Mathematics, Hamidia Arts and Commerce College, Bhopal (M. P.).

*†Nigam, S. S., M.Sc., Ph.D., D.I.C., Reader in Chemistry, University of Saugar, Sagar.

Oak, Mr. Justice V. G., B.Sc., (Hons.), I.C.S., 1A-Beli Road, Allahabad-2.

Ojha, D. N., M.Sc., D.Phil., Prof. and Head of the Geology Department, Science College, Patna.

Ojha, S. N., M.Sc., Assistant Rice Specialist, Agricultural Research Institute, Pusa (Dt. Darbhanga) Bihar.

Ojha, S. N., M.Sc., Asstt. Professor of Agriculture, Tirhut College of Agriculture, Dholi, Muzaffarpur, Bihar.

Pagey, S. S., M.Sc., Lecturer in Mathematics, Govt. H. S. School, Susner (M. P.), c/o Jagirdar P. O., Susner, Distt. Shajapur.

Pahwa, Dharam Veer, M.Sc., Senior Research Assistant, Central Inland Fisheries Research Sub-station, 30, Panna Lal Road, Allahabad-2.

*†Pal, N. L., D.Sc., Plant Physiologist, Central Tobacco Research Institute, Rajamundry.

Pande, Vinod Mohan, M.Sc., Research Scholar, College of Technology, Banaras Hindu University, Varanasi-5.

Pendse (Miss) Asha, M.A., Research Scholar, Deptt. of Maths., University of Rajasthan, Jaipur-4.

*†Pandey, B. P., D.Sc., Professor of Parasitology, U. P. College of Veterinary Science and Animal Husbandry, Mathura.

Pandey, K. C., M.Sc., Lecturer in Zoology, Lucknow University, Lucknow.

Pandey, Ravi, M.Sc., Head of the Department of Zoology, C. M. D. Degree College, Bilaspur (M. P.).

*Pandeya, S. C., M.Sc., Ph.D., Reader in Botany, University School of Sciences, Ahmedabad-9.

Pandit, C. S., M.Sc., Lecturer in Chemistry, Holkar Science College, Indore (M. P.).

Panigrahi, Gopinath, B.Sc., (Hons.), M.Sc., Ph.D., Regional Botanist, Central Circle, Botanical Survey of India, 10, Chatham Lines, Allahabad-2.

*†Pannikar, N. K., M.A., D.Sc., F.A.Sc., F.N.I., F.Z.S.I., Director, Indian Programme, Indian Ocean Expedition, Council of Scientific and Industrial Research, Rafi Marg, New Delhi-1.

Parashar, B. P., M.Sc., *Member, Indian Mathematical Society and American Mathematical Society*, Asst. Prof. of Mathematics, College of Science, Raipur (M. P.).

Parihar, C. L., M.Sc., Lecturer in Mathematics, Maharaja College, Chhatarpur (M. P.).

†Paria, Gunadhar, D.Phil., D.Sc., Professor of Mathematics, Shri Govindram Seksaria Technological Institute, Indore (M. P.).

*†Parija, P., M.A., D.Sc., F.N.I., F.A.Sc., I.E.S. (Retd.), Vice-Chancellor, Utkal University, Vani Vihar, Bhubaneshwar (Orissa).

Parvatikar, S. R., M.Sc., Ph.D., Student, 26, New-wing Hostel, I. A. R. I., New Delhi-12.

Patel, C. M., M.Sc., Asst. Prof. in Mathematics, P. M. B. Gujrati College, Indore (M. P.).

Patel, Vishnu Shankar, M.Sc., Asst. Professor of Chemistry, M. V. Mahavidyalaya, Bhopal.

Pathak, Hari Datt, M.Sc., Assistant Professor of Chemistry, D. S. B. Government College, Nani Tal.

Pathak, R. S., M.Sc., Research Scholar in Mathematics, Banaras Hindu University, Varanasi-5.

Pathan, Mahmood Ahmad, M.Sc., Department of Mathematics, University of Rajasthan, Jaipur.

*Patil, Ramakant Pandurang, B.A., M.Sc., Ph.D., Botanist, Central Botanical Laboratory, 76, Acharya Jagdish Bose Road, Calcutta-14.

*†Paul, Ram Chand, M.Sc., Ph.D., F.R.I.C., Professor and Head of the Chemistry Department, Punjab University, Chandigarh-3.

*†Perti, O. N., M.Sc., D.Phil., Professor and Head of the Chemistry Department, M. L. N. Regional Engineering College, Allahabad.

Potay, S. K., M.Sc., Senior Scientific Assistant, House No. 11-1-419, Sitafal Mandi, Secunderabad (A. P.).

†Prakash, Nam, M.Sc., c/o Shri Agun Prasad, Kailawallen Street, Delhi Gate, Ghaziabad.

*†Prakash, Ved, M.Sc., Principal, R. S. D. College, Ferozepore City.

Prasad, A. R., M.Sc., Asst. Professor of Entomology, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur), Bihar.

*Prasad, Balbhadra, D.Sc., F.N.I., Department of Chemistry, Patna University, Patna-5.

†Prasad, B. N., M.Sc., Ph.D., F.L.S., F.B.S., Department of Botany, University of Lucknow, Lucknow.

Prasad, C. R., M.Sc., Ph.D., Assistant Agricultural Chemist, Agricultural Research Institute, P. O. Kanke, Ranchi (Bihar).

Prasad, Devendra, M.Sc., Ph.D., F.A.Z., Reader and Head of the Zoology Department, Science College, Patna-5.

Prasad, Mahendra, M.Sc., Dr.rer Nat., Reader in Botany, Ranchi College, Ranchi.

*†Prasad, Mata, D.Sc., F.R.I.C., F.N.I., Mathura Niwas, 4281 Pipal Mandi, Agra.

Prasad, P., B.Sc., (Hons.), M.A., Asst. Professor of Mathematics, L.S. College, Muzaffarpur.

Prasad, R. K., B.Sc. (Hons.), M.Sc., Ph.D., Lecturer in Chemistry, L. S. College, Muzaffarpur.

*†Prasad, S. N., M.Sc., D.Phil., Reader in Zoology, University of Allahabad, Allahabad.

*Prasad, S. S., M.Sc., Ph.D., Head of the Botany Department, L. S. College, Muzaffarpur (Bihar).

Prasad, Y. N., M.Sc., Lecturer in Mathematics, Engg. College, Banaras Hindu University, Varanasi-5.

†Puri, G. S., M.Sc., Ph.D., F.L.S., F.G.S., F.G.M.S., F.B.S., Head of the Dept., of Botany, Kawame Nkrumah University of Science & Technology, Kumasi, Ghana.

*Puri, V., M.Sc., D.Sc., F.B.S., F.A.Sc., F.N.I, Principal, Meerut College, Meerut.

†Purohit, D. N., M.Sc., Ph.D., c/o Pt. L. N. Purohit, Advocate, Naya Shahar, Idgah Bari, Bikaner.

Purushottam, G., M.A., Department of Mathematics, Science College, Osmania University, Hyderabad-Dn 7 (A. P.).

Raghuvanshi, S. S., M.Sc., D.Phil., Assistant Professor of Botany, Lucknow University, Lucknow.

*†Rai, M. M., M.Sc., D.Phil., Professor of Chemistry, Government Agricultural College, Rewa (M. P.).

Rai, P., B.V.Sc., & A.H., M.V.Sc., Assistant Professor of Parasitology, U.P. College of Veterinary Science and Animal Husbandry, Mathura.

†Rai, Rama Shanker, M.Sc., D.Phil., Department of Chemistry, University of Rajasthan, Jaipur.

Rai, U. K., M.Sc., D.Phil., Oil Seeds Specialist, Agricultural Institute, Sabour, (Bhagalpur).

Rajagopal, T., M.Sc., Research Scholar, c/o Dr. N. Ramayya, Deptt. of Botany, University College of Science, Osmania University, Hyderabad.

Rajulu, G., Sundara, M.Sc., Ph.D., Lecturer in Zoology, Thiagarajan College, Madurai-9 (M. S.).

Rajvanshi, S. C., M.Sc., Lecturer in Mathematics, Malaviya Regional Engineering College, Jaipur (Rajasthan).

Ramakrishnan, P. S., M.Sc., Ph.D., Department of Botany, Punjab University, Chandigarh.

*†Ramamoorthy, B., M.Sc., D.Phil., Assoc. I.A.R.I., Physical Chemist, Division of Chemistry, Indian Agricultural Research Institute, New Delhi-12.

Raman, S. S., M.Sc., Ph.D., Lecturer in Botany, Banaras Hindu University, Varanasi-5.

Ramaswamy, K. R., B.Sc., (Hons.), M.Sc., Ph.D., Lecturer in Zoology, Karnatak University, Dharwal (Mysore).

*†Ramdas, L. A., M.A., Ph.D., F.N.I., F.A.Sc., F.R.Met.Soc., National Physical Laboratory, New Delhi-12.

*†Ramiah, K., M.Sc., D.Sc., (Hony.), F.N.I., F.A.Sc., Swathi, XIX Cross Road, Bangalore-12.

Ram, Naresh Prasad, M.Sc., Lecturer in Zoology, Dept. of Zoology, S. P. Jain College, Sasaram (Shahabad).

*Ranade, J. D., M.Sc., Ph.D., A.Inst.P., Assistant Professor of Physics, University of Saugar, Sagar.

*†Randhawa, M.S., M.Sc., D.Sc., F.N.I., I.C.S., Adviser (Resources), Planning Commission, New Delhi-1

*†Ranjan, S., M.Sc., D.Sc., F.N.I., F.A.Sc., Vice-Chancellor, Agra University, Agra.

Rao, A. L. Jagannadha, M.Sc., Ph.D., Lecturer in Chemistry, Punjabi University, Patiala (Panjab).

Rao, D. Rama Krishna, M.A., Lecturer in Mathematics, Department of Technical Education, Nehru Nagar, Secunderabad (A. P.).

Rao, Digambar, M.Sc., Research Scholar in Botany, College of Science, Osmania University, Hyderabad–7.

Rao, D. Rameshwar, M.A., Research Scholar, 11-1-243, Sitafalmandi, Secunderabad.

Rao, G. Teeka, M.A., Reader, Department of Chemical Technology, Osmania University, Hyderabad–7.

Rao, K. M., M.A., Department of Mathematics, J. T. S. Govt. Polytechnic, Vijayawada (A. P.).

Rao, K. S., M.Sc., Lecturer in Zoology, Government Science College, Rewa.

Rao, M. Rama Mohana, M.A., Asstt. Professor of Mathematics, Deptt. of Mathematics, University Rhode Island Kingston, R. I. 2881. (U.S.A.).

†Rao, S. N., M.Sc., Ph.D., F.R.E.S., F.A.Z., Reader in Zoology, Department of Zoology, Marathwada University, Aurangabad.

Rao, V. V. L. N., M.A., Reader in Mathematics, Plot No. 6, Krishna Nagar Colony, Bholakpur, Secunderabad–3 (A. P.).

Rathie, P. N., M.Sc., Lecturer in Mathematics, M. R. Engineering College, Jaipur.

*Rawat, J. S., M.Sc., Ph.D., Assistant Professor, Department of Physiology and Biochemistry, U. P. College of Veterinary Science and Aminal Husbandry, Mathura.

*Raychaudhuri, S. P., M.Sc., Ph.D., D.Sc., F.R.I.C., F.N.I., Senior Specialist (Land Resources), Planning Commission, Yojana Bhavan, Parliament Street, New Delhi–1.

Rasul, S. H., B.Sc., (Hons.), M.Sc., Ph.D.Tech., F.P.S., F.G.S., Reader, Head of the Geology Department, Aligarh Muslim University, Aligarh.

*Ray, M., D.Sc., F.N.I., Principal, Agra College, Agra.

*†Roy, Arabinda, M.Sc., Ph.D., Professor of Physiology and Biochemistry, U. P. College of Veterinary Science, Mathura.

*†Roy, R. P., M.Sc., Ph.D., F.L.S., F.B.S., University Professor of Botany, Patna University, Patna–5.

Rusia, K. C., M.Sc., Lecturer in Mathematics, Govt. Engineering College, Jabalpur.

Sabherwal, Kailash Chander, B.A., M.A., Lecturer in Maths., Western Regional Institute for Technical Teachers Training, Bhopal.

Sabnis, J. H., M.Sc., Lecturer in Zoology, Zoology Department, College of Science, Nagpur.

*†Sadhu, D. P., M.Sc., Ph.D., F.N.I., Professor of Physiology and Nutrition Bengal Veterinary College, Calcutta-37.

Sahai, Rajendra, M.Sc., Asst. Professor of Botany, University of Gorakhpur, Gorakhpur.

*†Sahni, (Mrs.) Savitri, M.Sc., Director, Birbal Sahni Institute of Palaeobotany, University Road, Lucknow.

†Saksena, B. B. L., M.A., M.Sc., L. T., Assistant Professor of Botany, K. N. Govt. Degree College, Gyanpur, (Varanasi).

Sachdeva, S. K., M.Sc., Research Scholar, Dept. of Mathematics, Maharaja College, Chhatarpur (M. P.).

†Saksena, J. N., M.Sc., Ph.D., Professor of Zoology, Government Science College, Rewa (M. P.).

Saksena, K. M., M.Sc., Ph.D., Lecturer, Dept. of Mathematics, Ranchi University, Ranchi.

†Saksena, R. D., M.Sc., Ph.D., F.Z.S.I., c/o. PL 480 Projects, Dept. of Zoology, University of Allahabad, Allahabad.

*†Saksena, R. K., D.Sc., F.N.I., c/o Sri Pramod Kumar, 385/6 Sarat Chatterji Road, P. O. Botanic Gardan, Howrah-3.

*†Saksena, S. B., M.Sc., Ph.D., F.B.S., Professor and Head, Department of Botany, University of Saugar, Sagar.

†Sangal, Satendra Prasad, M.Sc., D.Phil., D.Sc., Reader in Inorganic Chemistry, Laxminarayan Institute of Technology, Nagpur.

Sant, H. R., M.Sc., Ph.D., Lecturer, Botany Department, Banaras Hindu University, Varanasi-5.

†Sarkar, D. C., Ph.D., Reader and Acting Head of the Physics Department, Muslim University, Aligarh.

Sarma, K. P., M.A., Research Scholar, Department of Mathematics, Osmania University, Hyderabad (A. P).

*Satyanarayana, Y., B.Sc., Ph.D., Ecologist, Central Arid Zone Research Institute, Jodhpur.

Saxena, V. P., M.Sc., Research Scholar, Deptt. of Mathematics, S. A., Technological Institute, Vidisha.

Saxena, P. K., M.Sc., Ph.D., Lecturer in Zoology, Department of Zoology, Bareilly College, Bareilly.

*†Saxena, B. B. L., M.Sc., D.Phil., Assistant Professor of Chemistry, University of Allahabad, Allahabad.

†Saxena, D. B., M.Sc., D.Phil., F.A.Z., M.Z.S., F.I.H.S., Fisheries Research and Aquarium, Dept. of J. & K., Govt. Marwan, Srinagar, Kashmir.

Saxena, R. K., M.Sc., Lecturer in Mathematics, Govindram Seksaria Technological Institute, Opp. Nehru Park, Indore.

Saxena, Ram Kishore, M.Sc., Ph.D., 276, Shiv Road, Ratanada, Jodhpur.

Saxena, S. C., M.Sc., Ph.D., D.I.C., F.R.E.S., Reader in Zoology, University of Rajasthan, Jaipur.

*†Sen, Bisheswar, B.Sc., Director, Vivekananda Laboratory, Almora.

Sen, D. N., D.Sc., Department of Botany, University of Jodhpur, Jodhpur.

Seth, J., B.Sc., (Ag.), M.Sc., Ph.D., Asst. Professor of Agronomy, Indian Agricultural Research Institute, New Delhi.

Shafi, S. Md., M.Sc., Lecturer in Zoology, Ranchi College, Ranchi.

†Shah, C. K., M.Sc., Ph.D., F.B.S., Reader in Botany, University School of Sciences, Botany Dept., Gujarat University, Ahmedabad-9.

Shah, Manilal Tribhovandas, M.Sc., Asst. Prof. in Maths., Mahatma Gandhi Road, Street No. 6, Indore (M. P.).

Shakuntala (Mrs.) V., M.A., Research Scholar, Deptt., of Maths., Osmania University, Hyderabad-7.

Shankar, Hari, M.Sc., D.Phil., Assistant Professor of Agricultural Chemistry, Govt. Agricultural College, Kanpur.

Sharma, A. P., M.Sc., Lecturer in Physics, Aligarh Muslim University, Aligarh.

Sharma, B. B., B.Sc., (Hons.), M.Sc., Ph.D., F.B.S., Department of Botany, University of Lucknow, Lucknow.

Sharma, Bhagirath Lal, M.A., Lecturer in Mathematics, Dept., of Applied Sciences, Punjab Engg., College, Chandigarh.

*†Sharma, D., M.Sc., D.Phil., Professor and Head of the Department of Physics, University of Gorakhpur, Gorakhpur.

*†Sharma, G. P., M.Sc., Ph.D., F.N.I., F.A.Z., F.I.A.Z., F.Z.S., F.Z.S.I., F.R.M.S., Professor and Head of the Zoology Department, Punjab University, Chandigarh-3.

Sharma, R. K., M.Sc., Research Scholar, Deptt., of Botany, B. H. U., Varanasi-5.

Sharma, K. C., Ph.D., Lecturer in Mathematics, University of Rajasthan, Jaipur.

*†Sharma, M. N., M.Sc., Ph.D., F.I.P.S., Grad. L.T.E., Grad.Brit. I.R.E., F.P.S., A. Inst.P., Lecturer in Physics, Lucknow University, Lucknow.

Sharma, Om Prakash, M.Sc., Lecturer in Mathematics, Holkar Science College, Indore (M. P.).

Sharma, P. C., M.Sc., Ph.D., Asst. Research Officer, Pharmacognosy, Unit., National Botanic Gardens, Lucknow.

Sharma, S. K., M.Sc., Junior Scientific Officer, Room No. 31, National Physical Laboratory, New Delhi-12.

Shetty, H. P. C., M.A., M.Sc., Research Officer, Central Inland Fisheries Research Institute, Sub-station, 30, Panna Lal Road, Allahabad-2.

Shiveshwarkar, S. W., B.Sc., M.A., I.C.S., Director General, Vigilance Ministry of Railways (Railways Board), New Delhi.

Shrivastava, M. M. P., Ph.D., Professor of Agriculture, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur) Bihar.

Shrivastava, R. K., M.Sc., D.Sc., Asst. Professor of Zoology, Nagpur University, L. I. T. Buildings, Nagpur.

Shukla, G. C., M.Sc., D.Phil., *Member of the Indian Society of Soil Sciences*, Asst. Prof. of Analytical Chemistry, Division of Chemistry, Indian Agricultural Research Institute, New Delhi-12.

Shukla, G. S., M.Sc., Ph.D., Reader in Zoology, University of Gorakhpur, Gorakhpur.

*Shukla, Ram Avatar, M.A., Ph.D., Professor and Head of the Department of Mathematics, Patna University, Patna-5.

Shukla, S. P., M.Sc., Research Scholar, School of Studies in Botany, Vikram University, Ujjain (M. P.).

Siddiqui, Md. Mahfooz Ali, M.A., B.Sc., Ph.D., Lecturer in Mathematics, Osmania University, Hyderabad-7 (A. P.).

*Sidhu, G. S., B.Sc., (Hons.), M.Sc., Ph.D., Director, Regional Research Laboratory, Hyderabad-9.

*†Singh, Amar, M.Sc., D.Phil., Reader in Botany, University, of Allahabad, Allahabad.

Singh, Anmol, M.Sc., Lecturer, Dept. of Zoology, Govt. Gandhi Memorial Science College, Jammu (J. & K.)

†Singh, Babu, M.Sc., Ph.D., D. I. C., Professor of Botany, Government Agricultural College, Kanpur.

*Singh, Balwant, D.Sc., F.R.I.C., P.E.S.I., (Retd.) Head of the Chemistry Department, Punjabi University, Patiala.

*Singh, B. N., M.Sc., Ph.D., D.Sc., Director (Microbiology), Central Drug Research Institute, Lucknow.

Singh, Carol, M.Sc., Ph.D., Lecturer in Maths., Govt. Engineering College, Bilaspur.

Singh, C. M., M.Sc., Ph.D., Director, Indian Veterinary Research Institute Izatnagar (U. P.).

Singh, C. P., M.Sc., Research Scholar, Dept. of Zoology, University of Jodhpur, Jodhpur.

Singh, D. N., M.Sc., Ph.D., Lecturer in Botany, Science College, Patna-5.

Singh, D. N., Ph.D., Principal, Bihar College of Engineering, Patna.

Singh, D. V., M.Sc., Field Officer, Pests and Diseases, I.A.D.P., Ramghat Road, Aligarh.

†Singh, Eric John, M.Sc., D.Phil., North West Institute for Medical Research, 5651, West Addison Street, Chicago 34, Illinois (U.S.A.).

†Singh, Janardan, M.Sc., Lecturer, Entomology Section, College of Agriculture, Banaras Hindu University, Varanasi-5.

Singh, J. S., M.Sc., Research Scholar, Department of Botany, Banaras Hindu University, Varanasi-5.

Singh, (Mrs.) K. D., M.A., Ph.D., Lecturer, Dept. of Mathematics, Lucknow University, Lucknow.

Singh, Karan, M.Sc., Lecturer in Botany, University of Jodhpur, Jodhpur.

Singh, K. K., M.Sc., Lecturer in Chemistry, R. D. S. College, Muzaffarpur.

Singh, K. P., M.Sc., Asstt. Prof of Horticulture, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur) Bihar.

†Singh, M. K., M.Sc., Ph.D., Lecturer in Botany, Dept. of Botany, Science College, Patna University Patna-5.

Singh, M. P., M.Sc., Lecturer in Zoology, L. S. College, Muzaffarpur.

Singh, Prahlad, M.Sc., Lecturer, Dept. of Mathematics, Ranchi College, Ranchi.

Singh, Pratap, M.A., Research Scholar in Mathematics, Birla College, Pilani.

†Singh, P. N., M.Sc., D.Phil., Asst. Agricultural Chemist, Agricultural Chemistry Laboratory, Durgapur (Rajasthan).

Singh, Ram Gopal, M.Sc., Research Scholar, Dept. of Plant Physiology, College of Agriculture, Banaras Hindu University, Varanasi-5.

†Singh, Rattan, M.A., Asst. Prof. of Mathematics, Government Science College, Rewa, (M. P.).

Singh, R. B., B.A. (Hons.), M.A., Lecturer in Mathematics, L. S. College, Muzaffarpur.

Singh, R. M., B.Sc. (Hons.), M.Sc., Lecturer in Mathematics, L. S. College Muzaffarpur.

*Singh, R. N., M.Sc., D.Phil., Principal, Govt. Arts and Science College, Durg (M. P.).

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Singh, S. B., M.Sc., Ph.D., F.Z.S., F.R.E.S., Reader in Zoology, L. S. College, Muzaffarpur.

Singh, S. B., M.Sc., Research Officer, Central Inland Fisheries Research Sub-station, 19, Cant, Road, Cuttack-1 (Orissa).

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Sinha, M. K., M.Sc., Asst. Professor of Agricultural Chemistry, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur), Bihar.

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Sinha, S., M.Sc., Ph.D., Head of the Department of Botany, Agra College, Agra.

Somal, B. S., M.Sc., Research Scholar, Department of Botany, University of Saugar, Sagar.

Sood, M. L., M.Sc., Research Scholar, Zoology Deptt., Lucknow University, Lucknow.

Sreenivasulu, V., M.A., Ph.D., Senior Research Asstt. Dept. of Mathematics, Molkalmuru, Chitradurga, Mysore State.

†Sreeramulu, T., M.Sc., Ph.D., D.I.C., Reader in Botany, Andhra University, Waltair (A. P.).

Srivastava, A. S., M.Sc., D.Phil., Ph.D., Entomologist to Government and Officer-in-Charge, Plant Protection Service, U. P., Kanpur.

Srivastava, B. K., M.Sc., D.Phil., Asstt. Professor of Zoology, University of Saugar, Sagar.

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*†Srivastava, D. S., M.Sc., Ph.D., F.R.M.S., F.R.E.S., Professor and Head of the Department of Zoology, University of Saugar, Sagar.

*Srivastava, G. D., M.Sc., B-Beli Road, Allahabad-2.

Srivastava, Gopalji, M.Sc., Ph.D., Lecturer in Zoology, University of Gorakhpur, Gorakhpur.

*Srivastava, H. D., M.Sc., D.Sc., F.N.I., Director, Indian Veterinary Research Institute, Izatnagar.

Srivastava, H. M., M.Sc., Ph.D., Department of Mathematics, Jodhpur University, 202, Sardarpura C-Road, Jodhpur, (Rajasthan).

Srivastava, H. P., M.Sc., Lecturer, Department of Botany, University of Jodhpur, Jodhpur (Rajasthan).

Srivastava, J. P., M.Sc., D.Phil., Head of Botany Deptt. C. M. P. Degree College, Allahabad.

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*†Srivastava, M. D. L., D.Sc., Retired Professor and Head of the Department of Zoology, University of Allahabad, Allahabad.

Srivastava, M. P., M.Sc., D. Phil., Asstt. Plant Pathologist (Rice), Regional Rice Research Station, Kapurthala, (Panjab).

†Srivastava, O. N., M.Sc., D.Phil., Head of the Department of Zoology, K. N. Govt. College, Gyanpur, (Varanasi).

*†Srivastava, P. L., M.A., D.Phil., F.N.I., 7, Lajpatrai Road, Allahabad-2.

†Srivastava, (Miss) Pramila, M.A., D.Phil., D.Sc., Reader in Mathematics, Banaras Hindu University, Varanasi-5.

Srivastava, P. S., M.Sc., Department of Zoology, S. B. R. College, Bilaspur (M. P.)

Srivastava, R. B., M.Sc., Lecturer in Botany, M. S. College, Motihari, Bihar.

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†Srivastava, R. K., M.V.Sc., Ph.D., Asst. Professor of Physiology, College of Veterinary Science and Animal Husbandry, Mathura.

Srivastava, R. K., M.Sc., D.Phil., Senior Research Fellow, C. S. I. R., Department of Agricultural Botany, College of Agriculture, Banaras Hindu University, Varanasi-5.

Srivastava, R. K., M.Sc., D.Phil., Udai Pratap Agriculture College, Varanasi.

Srivastava, R. P., M.Sc., Head of the Physics Dept., S. B. R. College, Bilaspur (M. P.).

Srivastava, R. P., M.Sc., Ph.D., Lecturer in Zoology, School of Basic Sciences, University of Udaipur, Udaipur.

†Srivastava, S. K., B.Sc. (Hons.), M.Sc., Kokaghat, Uprahti, Rewa.

Srivastava, S. L., M.Sc., Lecturer in Botany, K. N. Government College, Gyanpur.

Srivastava, S., B.Sc. (Hons.), M.Sc., Asst. Professor of Agricultural Botany, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur) Bihar.

Srivastava, S. N., M.Sc., Professor of Agricultural Engineering, Tirhut College of Agriculture, P. O. Dholi (Dt. Muzaffarpur) Bihar.

Srivastava, S. N., M.Sc., Ph.D., (Luck)., Ph.D., (Cantab) F.R.I.C., Head, Chemistry Deptt., Agra College, Agra.

†Srivastava, S. N., M.Sc., D.Phil., Department of Zoology, L. S. College, Muzaffarpur.

Srivastava (Mrs.) Sarla, M.Sc., Research Scholar, Zoology Department, Lucknow University, Lucknow.

Srivastava, Shambhu Nath, M.Sc., 20, Viveka Nand Marg. Kashmiri Hotel, Allahabad.

Srivastava, S. P., M.Sc., D.Phil., Reader in Chemistry, University of Roorkee, Roorkee.

Srivastava, T. N., M.Sc., Junior Research Fellow, Botany Deptt., University of Gorakhpur, Gorakhpur.

*†Srivastava, U. S., M.Sc., M.Ed., D.Phil., Professor of Zoology, University of Bihar, Muzaffarpur.

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*Sur, N. K., D.Sc., F.N.I., 74, Tagore Town, Allahabad-2.

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†Swarup, K., M.Sc., D.Phil., Department of Zoology, University of Gorakhpur, Gorakhpur.

*Tandon, Amar Nath, M.Sc., D.Phil., Seismologist, Meteorological Office, Lodi Road, New Delhi-3.

Tandon, M. P., M.Sc., D.Phil., Assistant Professor of Botany, University of Allahabad, Allahabad.

*†Tandon, R. N., M.Sc., Ph.D., D.I.C., F.A.Sc., F.N.I., Retired Professor and Head of the Department of Botany, University of Allahabad, Allahabad.

*†Tandon, R. S., M.Sc., D.Phil., F.A.Z., F.H.S., Assistant Professor of Zoology, University of Lucknow, Lucknow.

*†Tandon, S. P., M.Sc., D.Phil., Professor and Head, Chemistry Department, University of Allahabad, Allahabad.

Tavathia, B. S., M.Sc., Ph.D., Assistant Professor in Mathematics, Birla Institute of Technology and Science, Pilani, Rajasthan.

*†Tewari, H. B., M.Sc., D.Phil., Ph.D., D.Sc., F.Z.S., F.R.M.S., Head of the Zoology Dept. University of Udaipur, Udaipur.

*Thakur, C., M.Sc., Ph.D., Principal and Regional Director, Agricultural Research Institute, Dholi (Dt. Muzaffarpur) Bihar.

*Thind, K. S., M.Sc., Ph.D., Reader in Botany, Punjab University, Chandigarh-3.

Tiagi, Yagya Datta, M.Sc., Ph.D., Assistant Professor of Botany, University of Saugar, Sagar.

Tiwari, Giriraj, M.A., M.Sc., Deptt. of Mathematics, Shri G.S.T.I. Indore.

†Tiwari, I. P., M.Sc., Assistant Professor of Zoology, Government Science College, Raipur.

Tiwari, M. N., M.Sc., Ph.D., Lecturer in Botany, Dept. of Botany, University of Jodhpur, Jodhpur.

*†Tiwari, R. D., M.Sc., D.Phil., Professor of Chemistry, University of Allahabad, Allahabad.

Tripathi, O. N., M.Sc., LL.B., Ph.D., Head of the Department of Chemistry, Govt. Degree College, Ambikapur, Distt. Sarguja (M. P.).

Tripathi, R. S., M.Sc., Ph.D., Lecturer in Botany, Deptt. of Botany, University of Gorakhpur, Gorakhpur.

Tripathi, Y. R., D.Sc., Deputy Director, Fisheries, Department of Animal Husbandry and Fisheries, Badshah Bagh, Lucknow.

Tripathy, A. N., M.Sc., Lecturer in Mathematics, L. S. College, Muzaffarpur.

Tsokos, Chris. Peter, M. S.. Ph.D., (Candidate) Research Scholar, Deptt. of Mathematics, University of Rhode Island, Kingston, R. I. U. S. A.

Upadhya, V. N., M.Sc , F.P.S., Professor of Physics, S. B. Garda College, Navsari.

Usman, Mohammad, M.Sc., Junior Research Fellow, Central Electro Chemical, Research Institute, Karaikudi-3.

*†Vachaspati, M.Sc., Ph.D., Prof. and Head of the Physics Department, University of Allahabad, Allahabad.

Varkey, T. J., M.Sc., Department of Chemical Engineering and Applied Chemistry, University of Toronto, Toronto, (Canada).

*†Varma, D. N., M.Sc., D.Phil., F. A. Z., New Darbhanga Colony, 29, C. Y. Chintamani Road, Allahabad-2.

Varshney, C. K., M.Sc., Ph.D., Lecturer in Botany, Departement of Botany, University of Delhi, Delhi-7.

*Venkataraman, G. S., M.Sc., Ph.D., F.N.G.S., Microbiologist (Algae), Division of Microbiology, Indian Agricultural Research Institute, New Delih-12.

Verma, Alakh Prakash, M.Sc., Lecturer in Maths., University, School of Studies in Maths., & Statistics, Vikram University, Ujjain (M. P.).

Verma, C. B. L., M.A., Professor of Mathematics, Science College, Raipur (M. P.).

Verma, D. M., M.Sc., Botanist, Eastern Circle, Botanical Survey of India, Woodlands Laitumkhurah, Shillong (Assam)-3.

Verma, G. S., M.Sc., Ph.D., F.L.S., F.R.Hort.S., F.B.S., Reader in Botany, University of Lucknow, Lucknow.

Verma, K. P., M.Sc., Principal, Govt. Degree College, Gopeshwar, Distt. Chamoli (U. P.).

Verma, R. C., M.Sc., Reader in Mathematics, Government Engineering College, Jabalpur.

Verma, (Mrs.) Sindhu, M.Sc., Ph.D., Senior Research Scholar, Genetics Section, Botany Branch, Forest Research Institute, New Forest, Dehra Dun.

Verma, S. C., M.Sc., (Hons.)., Lecturer in Botany, Punjab University, Chandigarh.

Verma, S. K. C., M.Sc., Asst. Professor of Agriculture, Tirhut College of Agriculture, Dholi (Dt. Muzaffarpur) Bihar.

Verma, Triloki Nath, M.Sc., Lecturer in Mathematics, S. K. K. Degree College, Etawah.

Verma, V. K., B.Sc., (Hons.), M.Sc., Lecturer in Geology, c/o R. S. Varma 38/19, Probyn Road, Universioy Flats, Delhi–7.

Verma, V. K., M.Sc., Ph.D., Professor, Department of Mathematics, Engineering College, Bilaspur (M. P.).

Verma, R. U., M.Sc., C.S.I.R., Fellow, Deptt., of Maths., and Astronomy, Lucknow University, Lucknow.

†Vyas, K. D., B.Sc., M.B.B.S., Assistant Professor of Bacteriology, Department of Home Science, University of Allahabad, Allahabad.

†Vyay, L. N., M.Sc., Ph.D., Head, Department of Botany, M. B. College, Udaipur, (Rajasthan).

Wadhwa, B. M., M.Sc., (Hons.), Systematic Botanist, Western Circle, Botanical Survey of India, 7, Koregaon Road, Poona–1.

*†Wadia, D. N., M.A., D.Sc., F.G.S., F.A.S., F.N.I., F.R.S., Geological Adviser to Govt. of India, Department of Atomic Energy, South Block, Central Secretariat, New Delhi.

*†West, W. D., M.A., Sc.D., F.A.S., F.N.I., Professor and Head of the Department of Applied Geology, University of Saugar, Sagar.

†Weyl, Nathaniel, B.Sc., F.I.A.L., Writer, 4201, S. Ocean Blyd., Delroy Beach, Fla. (U. S. A.).

Wilson, K. I., M.Sc., 101, P. G. Hostel, Old Wing, I.A.R.I., New Delhi–12.

*†Yadav, J. S. P., M.Sc.,Ag., Ph.D., A.I.A.R.I., Dip.For., F.C.S., Soil Chemist, Forest Research Institute and Colleges, P. O. New Forest, Dehra Dun.

†Yadav, K. L., M.Sc., D.Phil., Lecturer in Chemistry, Allahabad University, Allahabad.

Yadav, R. S., M.Sc. Lecturer in Physics, Muslim University, Aligarh.

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